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Recommendations for fish & wildlife program under the Pacific Northwest Electric Power Planning and Conservation Act

RECOMMENDATIONS FOR FISH AND WILDLIFE PROGRAM

UNDER THE

PACIFIC NORTHWEST ELECTRIC POWER

PLANNING AND CONSERVATION ACT

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RECOMMENDATIONS FOR FISH & WILDLIFE PROGRAM

UNDER THE

PACIFIC NORTHWEST ELECTRIC POWER

PLANNING AND CONSERVATION ACT

NORTHWEST POWER PLANNING COUNCIL

DECEMBER 1981

PREFACE

The Pacific Northwest Electric Power Planning and Conservation Act, Public Law 96-501, was enacted by Congress to provide an orderly public process for electric energy planning in the states of Idaho, Montana, Oregon and Washington and to ensure that adequate programs are developed for the mitigation, protection and enhancement of fish and wildlife along the Columbia River and its tributaries. The Northwest Power Planning Council has been established under the Act for the purpose of developing a regional fish and wildlife program and a regional electric energy and conservation plan.

The fish and wildlife recommendations contained in these volumes were received by the Council in response to the Council's request for recommendations from federal and state fish and wildlife agencies, Indian tribes and other entities in the Pacific Northwest, as required under Section 4(h)(2) of the Act. The fish and wildlife agencies and Indian tribes were requested to provide the following types of recommendations:

"(A) measures which can be expected to be implemented by the (Bonneville Power Admininstration) Administrator, using authorities under this Act and other laws, and other Federal agencies to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by the development and operation of any hydroelectric project on the Columbia River and its tributaries;

"(B) establishing objectives for the development and operation of such projects on the Columbia River and its tributaries in a manner designed to protect, mitigate, and enhance fish and wildlife; and

"(C) fish and wildlife management coordination and research and development (including funding) which, among other things, will assist protection, mitigation, and enhancement of anadromous fish at, and between, the region's hydroelectric dams." (Act, Section 4(h)(2))

The Act further requires that the Council give notice of these recommendations and make these recommendations "available to the Administrator, to the Federal, and the region's State, fish and wildlife agencies, to the appropriate Indian tribes, to Federal agencies responsible for managing, operating, or regulating hydroelectric facilities located on the Columbia River or its tributaries, and to any customer or other electric utility which owns or operates any such facility." (Act, Section 4 (h)(4)(A)) The Act also requires that notice be given to the public.

The Council must adopt and publish a program to protect, mitigate, and enhance fish and wildlife on the Columbia River and its tributaries by November 15, 1982, one year after the date these recommendations were due. To meet that deadline, the Council is requesting written comments on these recommendations, and any additional recommendations individuals or organizations wish to submit, by **February 5, 1982.** Additional recommendations must be accompanied by detailed, supporting information

and data. Following receipt of comments and additional recommendations, the Council will provide an opportunity for oral and additional written comments through public meetings.

To obtain additional copies of these volumes, or for further information, please call or write the Council at the location shown below. A reasonable charge will be made for all copies. These recommendations will also be available for review, without charge, at the Council headquarters in Portland, at the Council office in each state capitol in the region and at all Bonneville Power Administration offices.

All comments on these recommendations and all additional recommendations must be submitted to the Council in writing at the following address:

NORTHWEST POWER PLANNING COUNCIL
700 SW TAYLOR STREET, SUITE 200
PORTLAND, OREGON 97205
(503) 222-5161

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MAIN DIVIDER - AGENCY

THE NATIONAL MARINE FISHERIES SERVICE

THE U.S. FISH AND WILDLIFE SERVICE

THE COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION

THE WASHINGTON DEPARTMENT OF FISHERIES

THE WASHINGTON DEPARTMENT OF GAME

THE OREGON DEPARTMENT OF FISH AND WILDLIFE

THE IDAHO DEPARTMENT OF FISH AND GAME

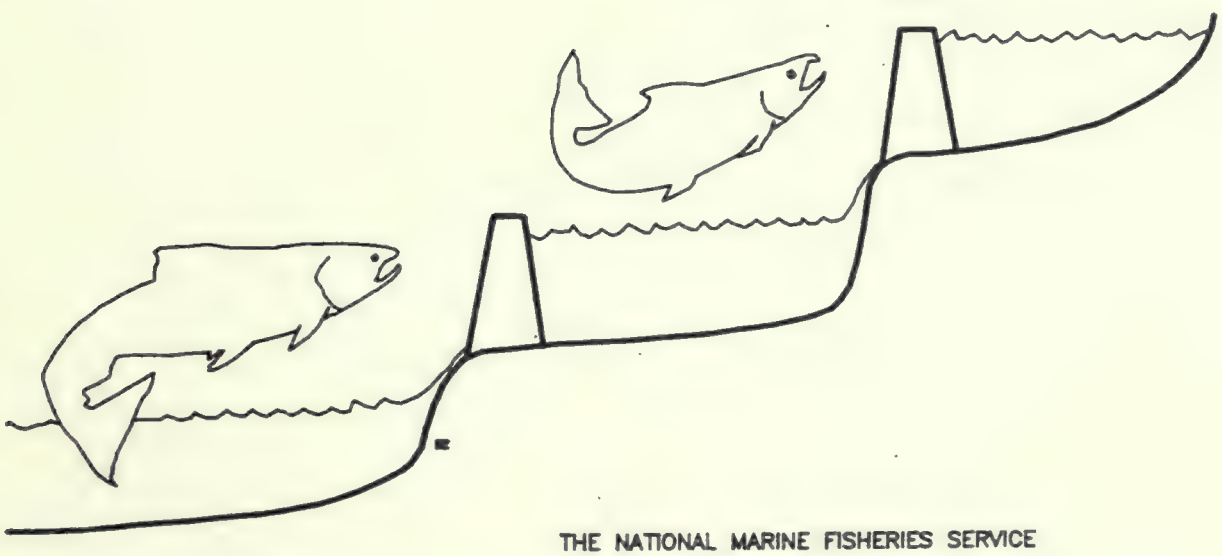
SUBDIVIDER - SECTION WITHIN AGENCY

EXECUTIVE SUMMARY - ANADROMOUS FISH

INITIAL RECOMMENDATIONS FOR THE PROTECTION, MITIGATION, AND ENHANCEMENT OF ANADROMOUS FISH IN THE COLUMBIA RIVER BASIN

EXECUTIVE SUMMARY

Submitted in accordance with Sec. 4(h) of the Pacific Northwest Electric Power Planning and Conservation Act by:



THE NATIONAL MARINE FISHERIES SERVICE

THE U.S. FISH AND WILDLIFE SERVICE

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Introduction

This document summarizes recommendations of the State and Federal fishery agencies and Indian tribes for the protection, mitigation, and enhancement of anadromous fish in the Columbia River Basin. The recommendations were prepared according to guidelines and standards of the Pacific Northwest Electric Power Planning and Conservation Act (P.L. 96-501) and submitted November 15, 1981 to the Northwest Power Planning Council in accordance with their request. A copy of the detailed recommendations may be obtained from the Council at the following address:

Northwest Power Planning Council
700 S.W. Taylor, Suite 200
Portland, Oregon 97205

Comments or concerns relating to these recommendations or other salmon and steelhead issues under the Power Act would be appreciated and can be addressed to any of the following fishery entities:

National Marine Fisheries Service
847 N.E. 19th Avenue
Portland, Oregon 97232

Oregon Department of Fish
and Wildlife
P.O. Box 3503
Portland, Oregon 97208

Idaho Department of Fish and Game
P.O. Box 25
Boise, Idaho 83707

Washington Department of Game
600 North Capitol Way
Olympia, Washington 98501

Washington Department of Fisheries
115 General Administration Bldg.
Olympia, Washington 98504

Fish and Wildlife Service
Lloyd 500 Bldg.,Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

Columbia River Inter-Tribal
Fish Commission
8383 N.E. Sandy Blvd.
Portland, Oregon 97220

Mandate of the Northwest Power Act

The enactment of the Pacific Northwest Electric Power Planning and Conservation Act (the Power Act) in December 1980 signaled a new commitment that the vast waters of the Columbia River and its tributaries would be managed with greater recognition of the need of fish and wildlife resources. The Act noted particularly that anadromous fish (Pacific salmon and steelhead trout) "are dependent upon suitable environmental conditions substantially obtainable from the management and operation of the Federal Columbia River Power System and other power facilities" in the Basin.

The Power Act addresses several impediments that have traditionally plagued efforts to incorporate fishery needs into water and power management on an equitable basis. Recognizing the unique relationship between the production of electric power and the production of anadromous fish in the Columbia River Basin, the Act raises the protection, mitigation, and enhancement of these fish to a new major purpose of the regional power system. To implement this purpose, Section 4(h) of the Act requires the Northwest Power Planning Council to develop and adopt "a program to protect, mitigate and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries."

The Act and its legislative history emphasize the need to balance fisheries needs with the need to assure the Pacific Northwest "an adequate, efficient, economical and reliable power supply."

However, the Act and its legislative history also indicate that fish and power production have not been balanced in the past. There is abundant evidence only slightly masked by hatchery production, correlating the decline in salmon and steelhead runs of the upper Columbia and Snake Rivers with the development of hydroelectric facilities. (Figures 1-3) The Act contemplates that reasonable power losses and monetary costs are inevitable to protect, mitigate and enhance fish and wildlife.

Once the Northwest Power Planning Council adopts the Fish and Wildlife Program, fish and wildlife measures must be translated into effective action. To this end the Power Act imposes specific implementation requirements on Federal agencies. The Bonneville Power Administration (BPA) must use the BPA funds and authorities to protect, mitigate and enhance fish and wildlife consistent with the Fish and Wildlife Program. Further, other Federal agencies responsible for managing, operating or regulating hydroelectric facilities must exercise their responsibilities taking into account at each decisionmaking point "to the fullest extent practicable the program adopted by the Council." These agencies are to assure that fish and wildlife receive "equitable treatment" with the other purposes for which the system and facilities are operated.

If the Sec. 4(h) program is to strike a balance between use of the river for fish and power production, it must direct the way to an improvement in the treatment of anadromous fish runs in power planning and decisionmaking. This is the mandate of the Northwest Power Act.

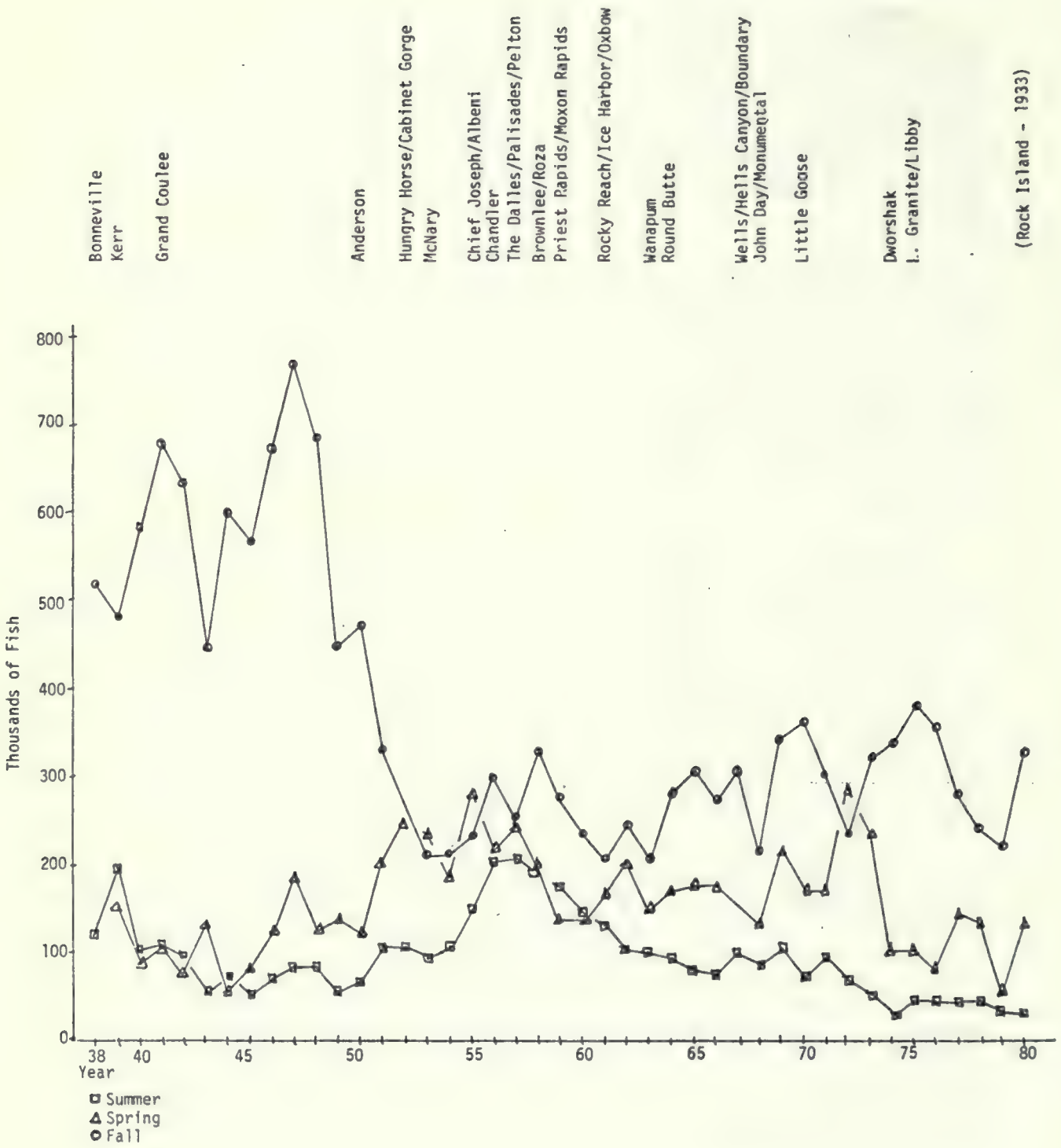


Figure 1. Estimated Numbers of Upriver Chinook Salmon in Runs Entering the Columbia River, 1938-80, and Major Dams in the Columbia System by Year of Completion.

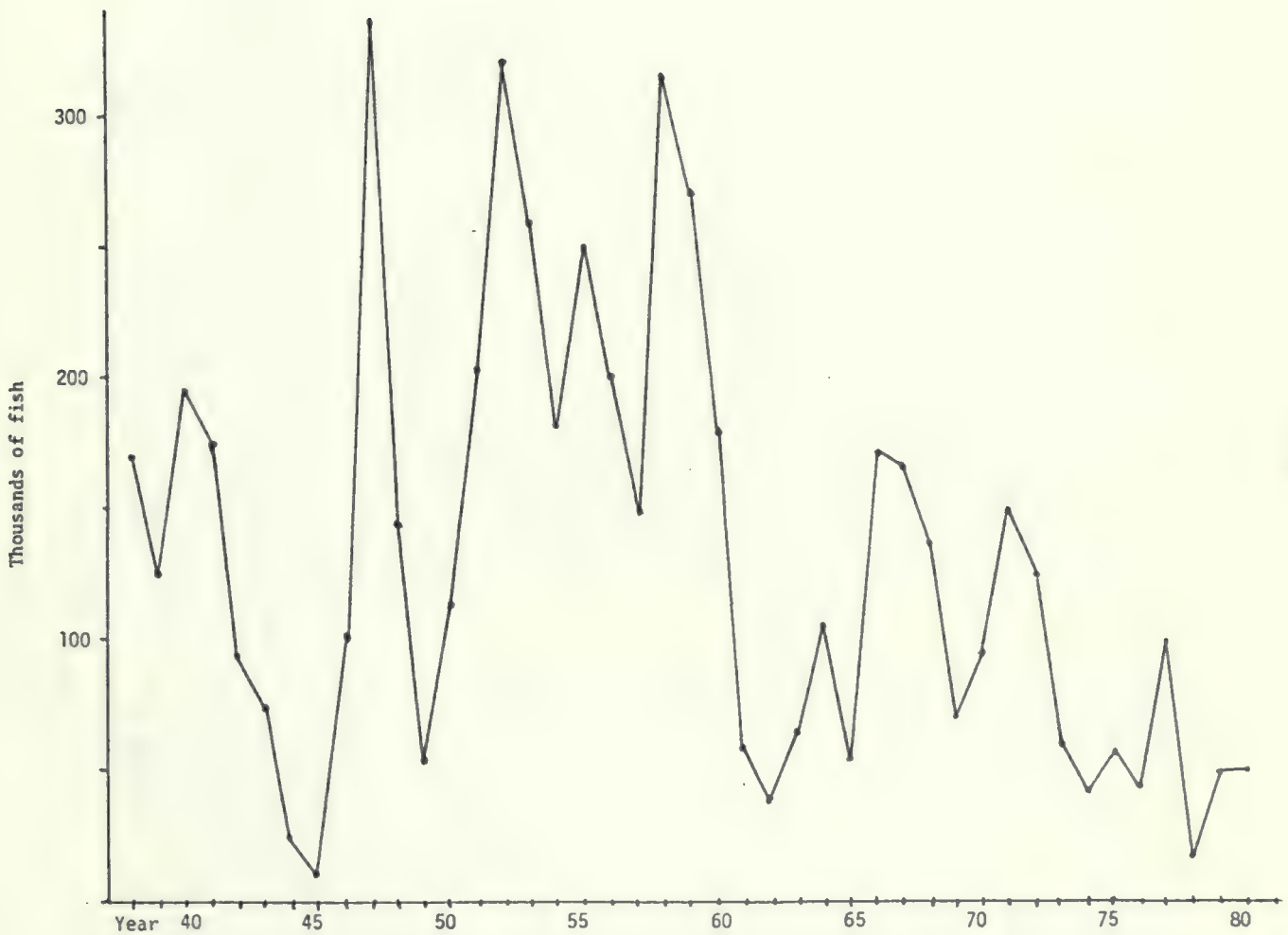


Figure 2. Estimated Numbers of Sockeye Salmon Entering the Columbia River, 1938-80.

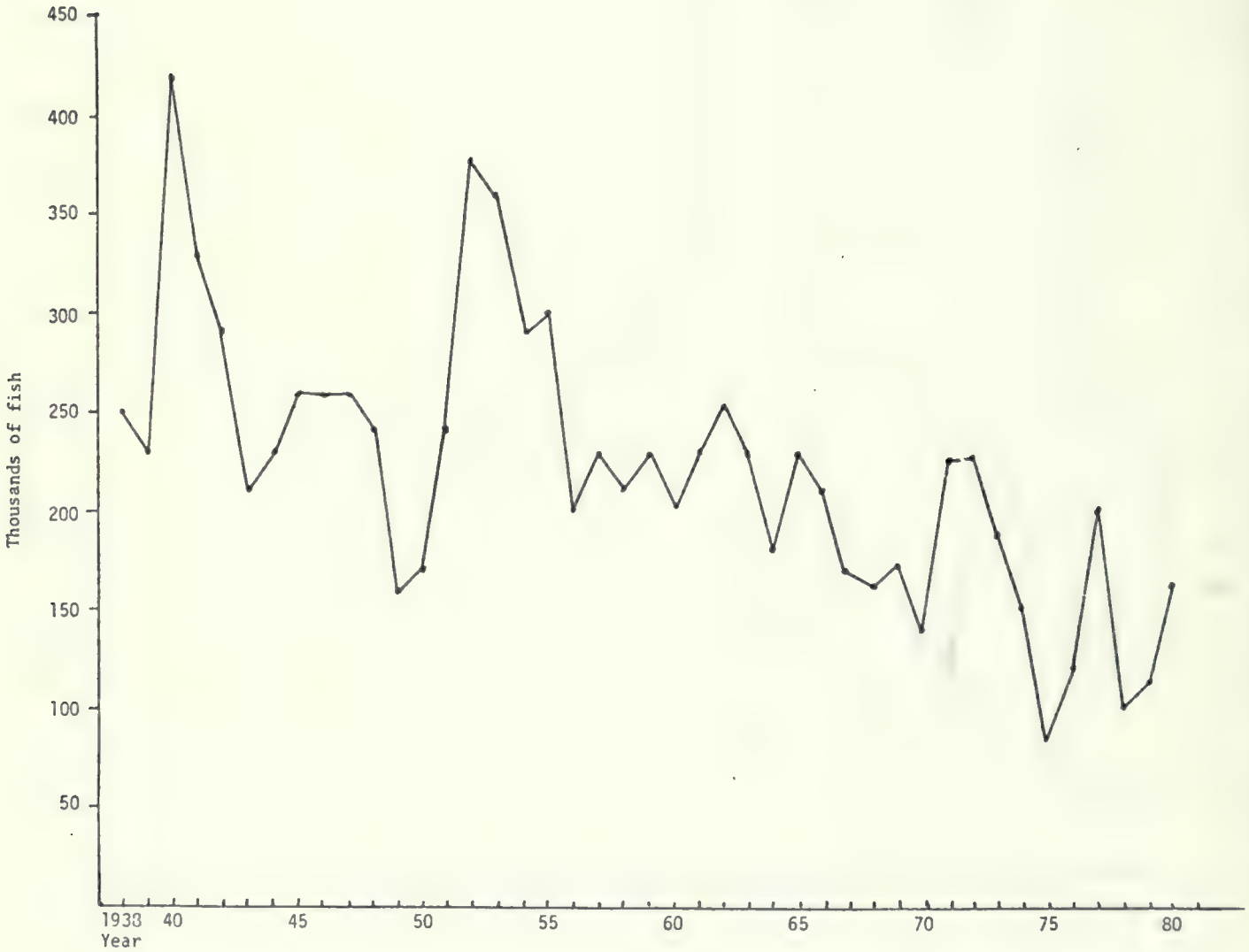


Figure 3. Estimated Number of Upriver Summer Steelhead Entering the Columbia River, 1938-80.

Indian Treaty Obligations

Indian treaty fishing and water rights, and the Federal government's trust obligations to protect those rights, are an additional obligation placed upon the Bonneville Power Administration and the Power Planning Council. The Indian's fishing rights are constitutionally protected property rights which may not be diminished except by the express action of Congress. Executive agencies may not abrogate Indian treaty rights nor diminish tribal resources. Indian treaty fishing rights include the right to protect the habitat of the fish. Without that right, the fishing right becomes meaningless.

In addition to the treaty fishing rights and the habitat protection right, the tribes have reserved water rights which may be asserted to protect the fish throughout their life-cycle. These water rights are prior in time to other water rights in the region, and thus must be satisfied before the rights of later water users.

Complementing these treaty fishing and water rights its the obligation of agencies of the Federal goverment to preserve, protect, and enhance tribal assets. For 150 years, the U.S. Supreme Court has consistently recognized this correlative duty. Analogizing to common law trust principles, the Supreme Court has placed an obligation on Federal agencies to protect treaty assests and to use agency expertise and skill to make trust property productive. Most important, the agencies' paramount obligation is to manage the tribal resources solely in the interest of the tribes. Courts consistently have held that an agency can not "balance" tribal interest against the interests of other parties. To make a "judgment call" which does balance tribal interests is an abuse of discretion and not legally permissible. Thus, if an agency's proposed action may affect treaty fishing or water rights, the agency's discretion is limited by its affirmative duty to protect and enhance these tribal resources.

The Power Act reaffirms these general principles. Section 10(e) states that "nothing in this Act shall be construed to affect or modify any treaty or other right of an Indian tribe." 16 U.S.C. § 839g (e). The program which the Council must prepare pursuant to Sec. 4(h) -- to "protect, mitigate and enhance" fish and wildlife affected by past, present and future development -- must be "consistent with the legal rights of appropriate Indian tribes in the region." 16 U.S.C. § 839 (b)(h)(6). Neither the Council nor any agency of the Federal government may infringe these rights; moreover, Federal agencies must affirmatively act to protect and enhance tribal assets. The passage of the Power Act reaffirms Congress's recognition of these rights and the Federal government's correlative duties.

Development and Coordination of Recommendations by Fishery Agencies and Indian Tribes

Section 4(h) of the Power Act directs the Power Planning Council to request from the Federal, and the regions' State fish and wildlife agencies and appropriate Indian tribes their recommendations for:

(a) Measures to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat affected by the development and operation of any hydroelectric project on the Columbia River and its tributaries;

(b) Objectives for the development and operation of such projects on the Columbia River and its tributaries in a manner designed to protect, mitigate, and enhance fish and wildlife, and

(c) Fish and wildlife management coordination and development, including funding, to assist protection, mitigation and enhancement of anadromous fish at and between the region's hydroelectric dams.

All of these recommendations are to be accompanied be detailed information and supporting data.

It was readily apparent that the responsibilities of the Council and needs of the fishery agencies and tribes would be served best if a coordinated effort was made to respond to the Council's solicitation.

An Ad-hoc Executive Committee (AEC) was formed, representing fish and wildlife agencies and Indian tribes. Active participants addressing anadromous fish issues included the National Marine Fisheries Service, Fish and Wildlife Service, Washington Department of Fisheries, Washington Department of Game, Columbia River Inter-Tribal Fish Commission (representing the fish and wildlife committees of the Columbia River Treaty Tribes), Oregon Department of Fish and Wildlife, and the Idaho Department of Fish and Game. AEC efforts were also coordinated with other Indian tribes and the Montana Department of Fish, Game and Parks.

The AEC was charged with evaluation and establishing overall goals and objectives for Fish and Wildlife Program recommendations as well as providing review and guidance for other aspects of the development of the recommendations. The committee also acted as a forum for the discussion of input from the general public and power entities. The National Marine Fisheries Service was designated lead agency staff for anadromous fish responsibilities.

Fishery Agencies and Tribes Goal and Objectives

A. The Anadromous Fish Goal

Based on the Power Act mandate and evidence concerning the decline of salmon and steelhead resources due to power development, the fishery agencies and tribes drafted their goal:

> TO PROTECT, MITIGATE, AND ENHANCE FISH AND WILDLIFE AND RELATED SPAWNING GROUNDS AND HABITAT TO THE EXTENT AFFECTED BY THE DEVELOPMENT AND OPERATION OF ANY ELECTRIC POWER FACILITY ON THE COLUMBIA RIVER AND ITS TRIBUTARIES IN A MANNER CONSISTENT WITH P.L. 96-501 AND OTHER APPLICABLE LAWS AND TREATIES.

The anadromous fishery goal, "to protect, mitigate, and enhance fish and wildlife and related spawning grounds and habitat to the extent affected by the development and operation of any electric power facility...," requires determining the effects of power development on upriver salmon and steelhead runs and what anadromous fish production levels should be attained to remedy those effects. The fishery agencies and Indian tribes have determined that the goal of the Council's fish and wildlife program should be restoration of upriver anadromous fish production to level approximating those that could have reasonably been maintained prior to the era of extensive mainstem power development initiated by construction of McNary Dam in 1953. This quantification of the goal is subject, however, to certain exceptions based on Indian treaty obligations (such as the production objective for coho salmon).

In Table 1, the pre-McNary Dam production level for each fish run is compared to existing run levels and shows a substantial difference. As explained below, restoration of production levels is the highest priority and must be achieved through reduction (mitigation) of passage losses concurrent with a reasonable level of compensation through increased artificial production and improved habitat for natural production. The fishery entities have recommended a phased approach to compensation, with Phase I being initiated immediately. The extent of Phase II would be determined based on the success of installed juvenile bypass and other facilities and improved river flows.

B. Objectives and Recommendations

Six objectives, biological and institutional, were drafted to guide developemnt of anadromous fish recommendations directed at achieving the goal. The objectives and recommendations are intended to provide the cornerstone of the anadromous fish portion of the Northwest Power Planning Council's Fish and Wildlife Program. The recommendations direct action at Federal power projects operated by the Corps of Engineers and the Bureau of Reclamation and at projects operated by public and private utilities through licensing decisions of the Federal Energy Regulatory Commission. The recommendations also direct action and funding for

Table 1. Recomended Production Levels and Mitigation/Compensation Objectives (numbers of fish entering the Columbia River)

	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Coho	Summer Steelhead
Production Goals; Pre-McNary base run size	300,000	200,000	400,000	200,000	164,000	400,000
Current run levels 5-Yr. Ave. (1975-1979)	101,000	41,000	294,000	55,000	45,600	124,000
Continuing losses due to power development	199,000	159,000	106,000	145,000	118,400[1/]	276,000
Pending - Lower Snake River Compensation Plan	74,800	48,800	33,800	0	0	105,300
Phase I compensation	54,300	44,900	56,500	68,400	50,000[2/]	66,700
Remaining losses due to passage mortalities	69,900	65,300	15,700	76,600	68,400	104,000

1/ Coho run reduction due mainly to change in hatchery management.

2/ Not based on 5% mortality, as were other stocks.

fishery inprovements by the Bonneville Power Administration. Taken as a whole, the recommendations address the anadromous fishery problems in the Columbia Basin as related tp power development in a comprehensive manner.

Priority must be given in the Council's Fish and Wildlife Program to adoption of minimum flow regimes, installation of effective juvenile collection and bypass systems, and immediate compensation for anticipated unavoidable passage losses utilizing natural and artificial production techniques. Additionally, a top priority for improved salmon and steelhead runs is the need to incorporate fisheries' requirements, identified by fisheries personnel, at all relevant stages of power and river management decisionmaking.

The following is a description of the six anadromous fish objectives and component subobjectives:

OBJECTIVE 1: JUVENILE MIGRANT SURVIVAL

Minimize the Mortality Due to Impact at and Between Power Facilities of Juvenile Anadromous Fish Management Down the Snake and Columbia Rivers and Tributary Streams.

A major stage of the life cycle of Columbia River Basin anadromous fish is the migration of juvenile fish from rearing areas to the ocean. Successful migration to the ocean is essential if anadromous fish runs are to survive, particularly in upriver areas.

Dams located on the Columbia river and its tributaries have caused serious losses to migrating juvenile fish. From the upper reaches of the Snake and Columbia Rivers, fish must pass through or over as many as 8 or 9 dams, respectively, before reaching the ocean.

Mortalities to migrating fish are attributable to (1) delay of migration, primarily in reservior forebays; (2) mortalities from passing through turbines; and (3) predation in zones both upstream and downstream of the dam.

-Delay of Migration. Fish migrating to the ocean are carried with the river, and therefore travel more rapidly in a free-flowing river with high velocities than in an impounded river with low velocities in the impoundments. Traveling through the reservoirs extends the amount of time it takes for migrating salmonids to reach the ocean. Fish are further delayed in forebays by seeking a way past the dam. In some cases, these combined delays can result in "holding over" of fish in the forebays and a premature end to migration. In general, fish that fail to migrate to the ocean do not mature, and cannot contribute to commercial, sport, and tribal fisheries, or reproduce and contribute to succeeding generations.

Subobjectives concerning juvenile migrant survival are directed at minimizing losses due to delayed migration by providing improved flow regimes to assist fish in reaching their ocean habitat. The primary

recommendation to the Power Planning Council is to adopt an initial minimum fishery flow regime as specified in Table 2 and Figures 4 and 5. Operation of the Federal Columbia River Power System to meet these flows would increase juvenile fish survival while having only a minimal impact on the reliability and efficiency of the Northwest's power supply. Because Indian treaty obligations are not subject to a fish-power balancing, the Columbia Inter-Tribal Fish Commission does not endorse other than optimal fishery flows in the Columbia Basin.

-Turbine Caused Mortality. In normal hydroelectric dam operations, where all of the water is passed through the turbines, juvenile fish will eventually be carried through those turbines. Regardless of turbine type, substantial numbers of migrating fish are killed in passing through turbines, with losses ranging from 10-30 percent per powerhouse and system-wide losses of over 90 percent in dry years, when no water is spilled. Losses of fish passing through turbines are generally referred to as "direct" turbine mortality.

Two subobjectives, were established, addressing the need to minize direct mortalities to migrating juvenile fish through the development and installation of bypass systems which successfully pass fish around, rather than through, turbines. Bypass systems protect both wild and hatchery fish. Another subobjective addresses avoidance of turbine and other mortalities - through collection and transporation of juvenile fish past dams in barges and trucks. Problems experienced in transportation of fish and inability to effectively collect all stocks of fish make this an interim or partial solution at this time.

To minimize turbine related mortality of juvenile salmon and steelhead, the fishery agencies and tribes have recommended that turbine intake bypass systems be installed at most Columbia and Snake River Dams which do not presently have such systems. These include some Corps of Engineers' dams and the five mid-Columbia public utility district dams. Transportation of fish in trucks and barges is also supported in recommendations to the Council as an interim measure until bypass systems are completed. Fish transportation in the Snake River may continue to be beneficial in the future, particularly during years of very low runoff. Fish transportation is viewed by the Columbia River Inter-Tribal Fish Commission as inconsistent with treaty obligations.

-Predation. Migrating juvenile fish are subject to increased predation due to hydroelectric development. Under pre-dam conditions, the majority of juvenile fish would be migrating in a free-flowing river and would have little exposure to predators, which are generally located in slack shallow waters. The dams have increased slack water areas in the river, creating more habitat for predators. Fish approaching a dam must pass through a zone upstream of the dam in which predators such as squawfish reside. The presence of predators in these forebay areas, combined with delay of juvenile fish in these same areas, can lead to unnaturally high predation mortalities. Predation also occurs in the perimeter zones of the tailrace, after the fish have passed through the dam. The stunned or injured fish entering this area are easy targets for predators. Predation in the tailrace area is usually referred to as "indirect" turbine mortality.

TABLE 2

RECOMMENDED WEEKLY AVERAGE MINIMUM FLOWS

X 1000 CFS

Month	Lower Granite	Priest Rapids	The Dalles
January	20	70	60
February	20	70	60
March	20	70	60
April			
1-15	40	70	120
16-25	85	70	160
26-30	85	110	200
May	85	130	220
June			
1-15	85	110	200
16-30	30	80	120
July			
1-15	30	80	120
16-31	20	110	140
August	20	95	120
September	20	40	90
October			
1-15	20	40	90
16-31	20	70	90
November	20	70	60
December	20	70	60

PRIEST RAPIDS DAM
FISHERY FLOW RECOMMENDATIONS

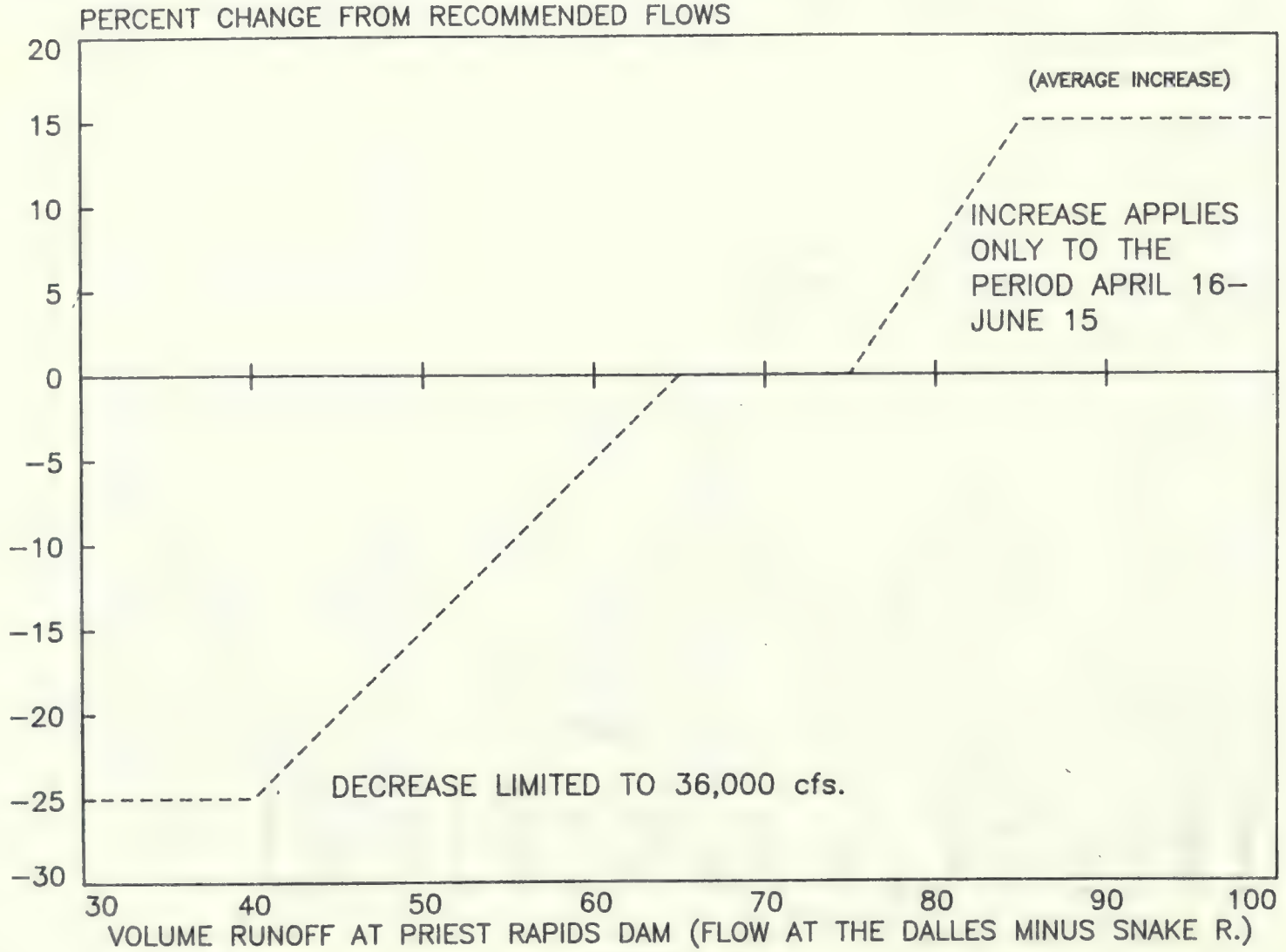


FIGURE 4

LOWER GRANITE DAM
FISHERY FLOW RECOMMENDATIONS

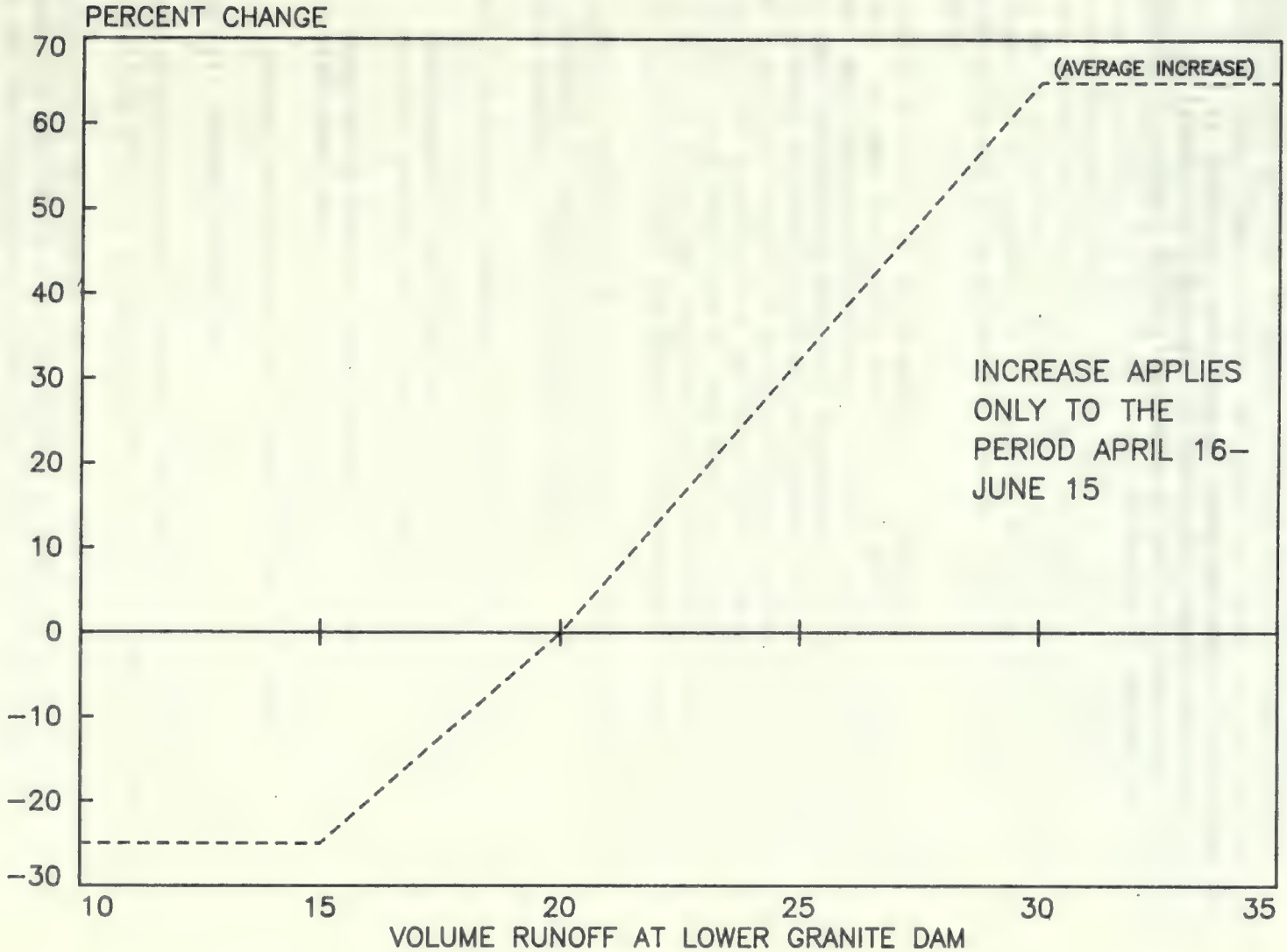


FIGURE 5

The primary recommendation presented to the Power Planning Council for addressing the problem of predation is:

That the Power Planning Council include in its Fish and Wildlife Program research to better estimate the relative contribution of predation mortality on migrating juvenile anadromous salmonids in the Columbia and Snake Rivers, and undertake necessary procedural and scientific processes required to potentially allow the use of Squoxin for limited control of squawfish.

OBJECTIVE II: ADULT MIGRANT SURVIVAL

Minimize the Mortality due to Impacts at and Between Power Facilities of Adult Anadromous Fish Migrating up the Columbia and Snake Rivers and Tributary Streams for Improved Escapement and Harvest

Hydroelectric projects greatly impact the migration and survival of adult anadromous fish. The mature fish can most successfully complete their upstream spawning migration when favorable passage conditions exist at each hydroelectric facility. Efficient, undelayed passage requires well designed, properly maintained fish ladders. Additionally, significant attraction flows to guide the fish toward the ladder entrances are a necessity. Flow conditions across the entire powerhouse and spillway must be regulated to achieve maximum guidance to the fishways and minimize any false attraction towards unladdered sections of the project.

Causes of mortality of adult salmon and steelhead have been studied at the dams. At many dams, delay and injury of adults is believed to be minor under most operating conditions. However, at other dams, such as John Day, adult mortalities have been documented as high as 20 percent. While the effects of adult losses at any single facility can be substantial, the cumulative impacts of delay and injury caused by passage of several dams is of great concern for those stocks bound for the upper basin. Studies have shown that as more dams were constructed in the migratory path of salmon and steelhead bound for the Snake River drainage, productive success declined for those that reached the spawning grounds.

In summary, improvement in adult guidance and passage over the hydroelectric projects is required to improve escapements and provide a harvestable surplus of fish in the upper river.

Adult fish passage recommendations to the Council include:

1. Improvement of adult passage conditions at numerous hydroelectric projects on tributary streams,

2. Adoption of flow and spill criteria at Columbia and Snake River dams, and

3. Improved operation and maintenance of adult fishways.

OBJECTIVE III: NATURAL PRODUCTION

Maximize the Production of Natural Habitat of Anadromous Fish Populations Affected by Hydroelectric and Other Power Development

Hydroelectric development has directly affected the productivity of anadromous fish habitat by blocking access to spawning ground, inundating spawning and rearing areas, and degrading habitat downstream of the project. The accumulative effects of hydro projects have reduced

escapements to some portions of the upper basin to the point where existing habitat is insufficiently seeded to achieve potential productivity.

Revitalizing natural production is of great importance to the continuance and management of anadromous fish. Genetic diversity of the fish stocks, so important to the long-term survival and improvement of the species, has been preserved by natural production. Without concerted efforts directed towards restoring natural production, the combined effects of continued hydropower operations and mixed stock fisheries will limit the genetic pool and the ability of the species to adapt to changing environmental conditions.

While natural production is critical as a safety or survival factor, it also contributes greatly to the total harvest of anadromous species from the Columbia Basin. Additionally, the wide distribution of natural production provides valuable distribution of harvest and aesthetic benefits to the public within the Basin.

Recommendations have been submitted which address the effects of Columbia and Snake River power operations on the last remaining mainstem spawning habitat. These two unique and productive areas have been specifically isolated from the other problem areas due to their relationship to major power operations and special consideration in the Act. Attention is also directed towards restoring other habitat in the Basin which has been degraded by hydroelectric operations. Improvements in these areas would mitigate the effects of the power projects.

Recommendations are included to allow consideration of enhancing habitat not directly affected by hydroelectric operations but needed to offset unavoidable fish or habitat losses caused by power generation elsewhere in the Basin. The fish stocks produced in these habitats may be seriously affected by hydroelectric operations on their migrations to and from the ocean. This form of habitat improvement provides a means of compensation in a manner complimentary to that addressed by hatcheries.

Another form of compensation, the restoration or provision of access for fish to habitat areas not now available for production is also recommended. Increased production from such areas would offset losses caused by power generation elsewhere.

Numerous recommendations specific to hydroelectric projects have been made to reduce the adverse impacts of their operation on anadromous fish. These address tributary projects along with the operational effects of Priest Rapids and Hells Canyon Dams on fish spawning in the Columbia and Snake Rivers, respectively.

Over 50 recommendations have been included to initiate habitat improvement projects to increase salmon and steelhead populations in stream areas not directly affected by hydroelectric operations. Such production increases are intended to help meet the fish compensation

debt caused by mainstem passage problems. Major recommendations include the construction of the Bumping Lake Enlargement Project to rehabilitate the Yakima River and riparian restoration projects on numerous streams in Oregon and Idaho.

OBJECTIVE IV: ARTIFICIAL PRODUCTION

Increase and Improve Artificial Production of Anadromous Fish Populations and Where Necessary Supplement Natural Runs with Carefully Planned Hatchery Releases

Hatchery production has historically provided a means of compensating for lost habitat or fish mortalities caused by hydroelectric development. While the emphasis of our recommendations are towards reducing fish losses, unavoidable losses will continue. Compensation through increased artificial production is critically needed and is therefore recommended.

Hatchery production has to some extent provided for the continuance of sport, commercial, and Indian fisheries despite the extreme impacts of hydropower development in the Columbia River Basin. However, reductions in the fisheries, delay and inadequacy of passage improvements, and the need to supplement natural production all point to the need for significant increases and improvements in hatchery operations.

Recommendations were developed addressing the need to immediately construct certain additional hatcheries and to find additional sites for artificial production. The need to improve the quality of hatchery fish at existing compensation facilities to increase their survival and contribution to sport, commercial, and Indian fisheries, and escapement is also addressed.

Investigations of new concepts of artificial production required for compensation is recommended. Recent experience in hatchery construction and current economics require a vigorous assessment of small, low-capital hatchery designs. Also the availability of large volume water supplies of high quality has shrunk, requiring future hatchery designs and programs capable of utilizing more numerous small supplies.

The need to integrate operations of some hatcheries into a role complimentary to natural production is noted. Hatchery fish will be needed in numerous cases to supplement natural production. The hatchery practices needed to successfully achieve this goal must be developed and implemented.

Recommendations to the Power Planning Council include:

1. Research to develop a basin-wide compendium of existing hatchery site data and to identify and conduct exploration for new hatchery sites.

2. The construction of the Yakima and Umatilla hatcheries.

3. The development of low-capital salmon and steelhead production facilities.

4. Research to determine the best means of supplementing upriver natural production with hatchery fish.

OBJECTIVE V: POWER PLANNING AND MANAGEMENT

Plan, Manage, and Operate the Federal Columbia River Power System and Other Power Generation Facilities to Provide Equitable Treatment for Fisheries Co-Equal to that for Power Generation.

Much of the decline of anadromous fish runs can be attributed to the failure of institutions responsible for power planning and river management, to adequately address fishery needs. Unless these institutions re-orient their decisionmaking and accept the fact that fishery interests are a legitimate partner in the management and operation of the power system, all of the substantive recommendations to improve fisheries will meet the same fate as previous efforts. The Power Act provides a new mechanism for improvement, but improvement will only occur with the cooperation of responsible utilities, power managers, and power coordinators.

Traditionally, fishery needs have been treated as a secondary or "soft" constraint in the operation of the river, while power production has been considered as a primary or "hard" constraint. As a consequence, fishery needs are only taken into account after all major power system decisions have been made if they are taken into account at all. This approach is both disruptive and conflict ridden. In dry years, major political confrontations between fishery and power interests have become the norm.

The current situation cannot continue. Either the institutions responsible for power planning, management, and operation must modify their basic assumptions for operating the river to include equitable treatment of fisheries, or the ultimate extinction of upriver runs must be accepted. Realistically, there is no middle ground.

To improve power planning and river management, the fishery agencies and tribes have recommended Bonneville Power Administration report on power system decisionmaking processes; formal agreements to reflect fisheries considerations in the U.S.-Canada Columbia River Treaty, the Pacific Northwest Coordination Agreement, and power management by the Bonneville Power Administration, Corps of Engineers and Bureau of Reclamation; the use of fishery flow criteria in power planning; and a Bonneville Power Administration system-wide annual operating plan which reflects fisheries needs. Additionally, the agencies and tribes recommend

that all BPA decisions (e.g. rates, billing credits, resource acquisition, environmental cost-benefit methodology, contractual arrangements, and load forecasting) reflect equitable treatment of fisheries. For new hydroelectric projects proposed for licensing by the Federal Energy Regulatory Commission or for BPA approval, new substantive and procedural criteria designed to protect fisheries are proposed.

OBJECTIVE VI: FISHERIES REPRESENTATION

Include Formal Fisheries Representation in all Matters of Power System Planning, Management, and Operation

Of necessity, the fishery agencies and Indian tribes must become more knowledgeable and sophisticated in their dealings with river management and the power system. Yet the agencies and tribes generally lack staff expertise in the complex planning, management, and operation of the projects or the system. Recognizing the importance of river management and power system management expertise in reconciling fisheries needs, representatives of the agencies and tribes have begun to educate themselves on the web of formal agreements and interrelationships that underlie the Northwest power system.

The benefits of these piecemeal efforts have underscored the need for the agencies and tribes to fully monitor and participate in important river management system decisions. The agencies and tribes have concluded that they required full-time power system and river management expertise if their interests are to be represented in these functions. They have also concluded that these functions are critical for the protection, mitigation, and enhancement of fisheries.

As a result, the fishery agencies and tribes have recommended that Bonneville Power Administration, the Corps of Engineers, and the Bureau of Reclamation establish a formal review process to obtain agency and tribal input to power-related decisionmaking. To support fisheries participation, funding is also recommended for three fishery positions, a Fishery Operations Manager, a Fishery/Energy Liaison Specialist, and a Power Management Analyst.

Conclusion

After the Power Planning Council reviews the recommendations, solicits public input, and shapes the recommendations and input into a comprehensive fisheries program, the job has just begun. Recommendations and program measures are only so many words unless promptly and effectively acted upon by the Bonneville Power Administration, the Federal Energy Regulatory Commission, the Corps of Engineers, the Bureau of Reclamation, and public and private utilities.

Under the Power Act, the primary responsibility for implementation of the fisheries program will fall on Federal agencies. The Federal agencies responsible for managing, operating, and regulating power projects must:

-- exercise their responsibilities consistent with the purposes of the Act to adequately protect, mitigate, and enhance fisheries, including related spawning grounds and habitat,

-- provide equitable treatment for fisheries with other project purposes,

-- exercise their responsibilities taking into account at each stage of decisionmaking to the fullest extent practicable, the fisheries program, and

-- consult with the fishery agencies and tribes in carrying out these obligations.

Under the Power Act, the Bonneville Power Administration has even more affirmative fisheries obligations than those described above. The Bonneville Power Administration must use all of its funding and authorities consistent with the fisheries program.

Finally, it is of utmost importance that the Power Planning Council oversee the actions of the Bonneville Power Administration and other Federal agencies to assure full compliance of each's duty to implement the Fish and Wildlife Program.

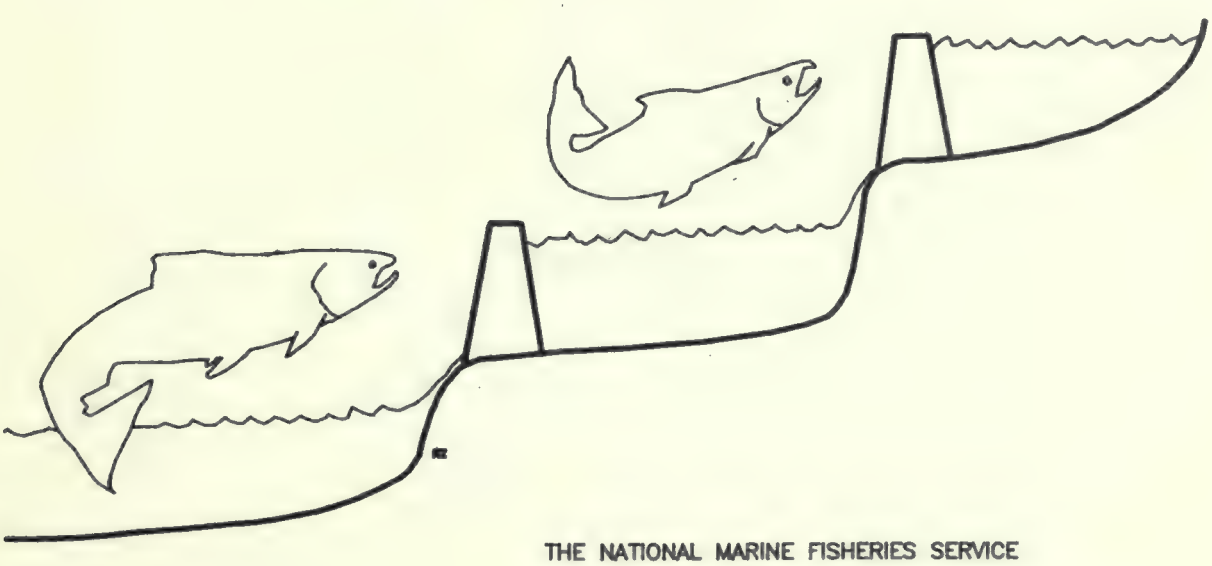
Of necessity, these are only initial recommendations of the fisheries agencies and tribes. The Fish and Wildlife Program adopted by the Council will be dynamic, particularly during its development and initial implementation. Through a dynamic process, including continued involvement of the Power Planning Council, the fishery agencies and tribes have high expectations that the ultimate goal--improvement of anadromous fish runs--will be achieved for commercial, recreational, and tribal fisheries and the benefit of all citizens of the Northwest.

SUBDIVIDER - WITHIN AGENCY

ANADROMOUS FISH

INITIAL RECOMMENDATIONS FOR THE PROTECTION, MITIGATION, AND ENHANCEMENT OF ANADROMOUS FISH IN THE COLUMBIA RIVER BASIN

Submitted in accordance with Sec. 4(h) of the Pacific Northwest Electric Power Planning and Conservation Act by:



THE NATIONAL MARINE FISHERIES SERVICE

THE U.S. FISH AND WILDLIFE SERVICE

THE COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION

THE WASHINGTON DEPARTMENT OF FISHERIES

THE WASHINGTON DEPARTMENT OF GAME

THE OREGON DEPARTMENT OF FISH AND WILDLIFE

THE IDAHO DEPARTMENT OF FISH AND GAME

INITIAL RECOMMENDATIONS FOR THE PROTECTION, MITIGATION, AND ENHANCEMENT OF ANADROMOUS FISH IN THE COLUMBIA RIVER BASIN

Submitted in accordance with Sec. 4(h)
of the Pacific Northwest Electric Power
Planning and Conservation Act by:

THE NATIONAL MARINE FISHERIES SERVICE
THE U.S. FISH AND WILDLIFE SERVICE
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THE WASHINGTON DEPARTMENT OF FISHERIES
THE WASHINGTON DEPARTMENT OF GAME
OREGON DEPARTMENT OF FISH AND WILDLIFE
IDAHO DEPARTMENT OF FISH AND GAME

November 1981

AD HOC EXECUTIVE COMMITTEE
of the
STATE AND FEDERAL FISH AND WILDLIFE AGENCIES AND INDIAN TRIBES
of the
COLUMBIA RIVER BASIN

November 13, 1981

Mr. Daniel J. Evans, Chairman
Pacific Northwest Electric Power Planning
and Conservation Council
700 S. W. Taylor St., Suite 200
Portland, Oregon 97204

Dear Chairman Evans:

By this letter we are transmitting initial recommendations in response to your June 10, 1981 request made in accordance with Section 4(h) of the Pacific Northwest Electric Power Planning and Conservation Act. These recommendations for the protection, mitigation, and enhancement of the resident fish, wildlife, and anadromous fish of the Columbia River and its tributaries represent the combined efforts of the following entities: National Marine Fisheries Service; Fish and Wildlife Service; Washington Departments of Fisheries and Game; Confederated Salish and Kootenai Tribes; Confederated Tribes of the Umatilla Reservation; Nez Perce Tribe of Idaho; Confederated Tribes of the Warm Springs Indian Reservation of Oregon; and Confederated Tribes and Bands of the Yakima Indian Nation. The Columbia River Inter-Tribal Fish Commission, representing the latter four tribes, participated in the development of and certified the recommendations dealing with anadromous fish.

The Federal and State fish and wildlife agencies and tribes have not yet tested all of the combinations of recommendations dealing with water levels and flows for improvement of resident fish, wildlife, and anadromous fish habitat. Some conflicts may remain between specific water management proposals, and where identified, the Ad Hoc Executive Committee will attempt to resolve these.

We are developing additional information on economic values and benefit/cost methodology which we will provide as it becomes available.

On behalf of the agencies and tribes, we express our appreciation for the cooperation of the Northwest Power Planning Council and assure you of the continuing cooperation and assistance of the Ad Hoc Executive Committee in your efforts to develop and adopt a responsive fish and wildlife program.

Sincerely,

Floyd G. Gurnsey for

William R. Wilkerson
Deputy Director
Washington Department of Fisheries
Cochairman

Wendell Oliver

Wendell Oliver
Applied Ecology Program Manager
Washington Department of Game.
Cochairman

CERTIFICATION

The Idaho Department of Fish and Game submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

for Monte A. Richard

Jerry M. Conley
Name

Director
Title

November 13, 1981
Date

Exceptions:

None

CERTIFICATION

The Oregon Department of Fish and Wildlife submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

Franklin R. Young

for John R. Donaldson Ph.D.
Name

Director
Title

November 13, 1981
Date

Exceptions:

None

CERTIFICATION

The National Marine Fisheries Service submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

H. A. Larkins
Name

Regional Director
Title

November 13, 1981
Date

Exceptions:

None

CERTIFICATION

The Columbia River Inter-tribal Fish Commission submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

Name

Executive Director
Title

November 13, 1981
Date

Exceptions:

As mentioned on page 170, the Columbia River treaty tribes do not subscribe to the flows recommended in Task 1.1.1, rather the tribes recommend that optimal flows be provided for downstream migration of salmon and steelhead. Consequently references to the Columbia River treaty tribes on page 206, paragraph 2 and paragraph 3 are not acknowledged.

CERTIFICATION

The Fish and Wildlife Service submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exception noted below.

Richard J. Myshak

Regional Director
Title

November 13, 1981
Date

Exception:

The Fish and Wildlife Service does not concur with recommendations contained in Task 1.1.1 regarding below minimum flow regimes in the Snake River during the critical smolt outmigration period of April 15 through June 15. We concur with the long term goal of Subobjective 1.1, but are unwilling to accept flows below minimum at any time during the critical outmigration period. To do so would be an abrogation of our anadromous fish responsibilities.

CERTIFICATION

The Washington Department of Fisheries submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

Lloyd A. Phinney for
Rolland M. Schmitten
Name

Director
Title

November 13, 1981
Date

Exceptions:

4.2.1(b): the Washington Department of Fisheries supports the development of fish rearing facilities on the Yakima Indian Reservation. We have not, however, had the opportunity to review the proposal for construction of the Klickitat Hatchery at Cascade Springs. We will welcome that opportunity to work with the Yakima Indian Nation and the Power Planning Council in this endeavor but can not specifically concur with these present proposals without that more detailed review.

4.2.5: the Department of Fisheries feels that any effort to transfer production from existing facilities and release sites must carefully consider the impact on both treaty and non-treaty fisheries. We recognize that this has been submitted by treaty Indian tribes as an expression of their treaty rights.

CERTIFICATION

The Washington Department of Game submits and endorses the Initial Recommendations for the Protection, Mitigation, and Enhancement of Anadromous Fish in the Columbia River Basin, subject to the exceptions noted below.

Fred W. Holm
Name

Interagency Coordinator
Title

November 13, 1981
Date

Exceptions:

None

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INTRODUCTION

The Columbia River Basin has an international reputation for extensive hydroelectric power production and extensive production of anadromous fish (salmon and steelhead trout). Both utilize the same water resources, both are of tremendous economic and social significance for the Pacific Northwest, and both face controversy due to production shortfalls. These descriptive similarities are not coincidental, for the past and future of power production and anadromous fish production are intertwined. In the past, the relation between power and fish has been one of competition, with power production prevailing at the expense of fishery resources. In the future, under the mandate of the Pacific Northwest Electric Power Planning and Conservation Act, the relation between power and fish should be one of cooperation, with a new balance struck between demands for power and the need to maintain and improve Northwest salmon and steelhead runs.

As a major step toward establishing this balance, the Pacific Northwest Electric Power Planning and Conservation Act (the Power Act) mandates the development of a comprehensive Fish and Wildlife Program for the Columbia River Basin. On June 19, 1981, the Pacific Northwest Electric Power and Conservation Planning Council (the Regional Power Council) called for program recommendations from the region's fish and wildlife agencies and Indian tribes. This document is the response of the National Marine Fisheries Service, the Fish and Wildlife Service, the Columbia River Inter-tribal Fish Commission, the Washington Departments of Fisheries and Game, the Oregon Department of Fish and Wildlife, and the Idaho Department of Fish and Game with respect to anadromous fish.

The document describes how the recommendations were developed; the current status of salmon and steelhead runs in the Columbia Basin; the ineffectiveness of past efforts to protect, mitigate, and enhance these runs; and the new mandate of the Power Act. Following this background information, the document sets out the actual recommendations of the fishery agencies and tribes, including a goal statement, objectives, subobjectives,

and tasks. The recommendations are accompanied by explanatory materials and supporting documentation as appropriate. Finally, the document concludes with a discussion of requirements and strategies for implementing the recommendations.

Within this document fishery agencies and tribes recommend measures to be implemented throughout the Columbia Basin. Recommendations for the upper Columbia above Bonneville Dam must be implemented as a first priority to rebuild the depressed runs in accordance with Indian treaty obligations and the status of depressed upper river runs. Following this the Lower Columbia River basin projects below Bonneville Dam are recommended for implementation.

CHAPTER A

Development of Recommendations

CHAPTER A
DEVELOPMENT OF RECOMMENDATIONS

The Ad-Hoc Executive Committee

Following passage of the Power Act, representatives of federal and state fish and wildlife agencies and Columbia Basin Indian tribes met to discuss a mechanism for developing comprehensive fish and wildlife recommendations and coordinating recommendations among the various agencies and tribes. In April 1981, the agencies and tribes established an Ad-Hoc Executive Committee (AEC) for this purpose. The AEC has active members representing Washington Departments of Fisheries and Game, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, Montana Department of Fish, Game, and Parks, Bureau of Indian Affairs, National Marine Fisheries Service, Fish and Wildlife Service, and Columbia River Inter-tribal Fish Commission (representing the Fish and Wildlife Committees of the Umatilla, Nez Perce, Yakima, and Warm Springs tribes). Other regional Indian tribes and Montana Department of Fish, Game, and Parks have been invited to participate in this coordination process. These tribes include the Confederated Tribes of Colville Reservation, Kalispell Indian Community, Spokane Tribe, Coeur d'Alene Tribe, Kootenai Tribe of Idaho, Shoshone-Bannock Tribes, and the Salish and Kootenai Tribes of the Flathead Reservation. The AEC has kept these parties informed of its progress. Co-chairpersons for the committee were designated to represent the three principal facets of the comprehensive Fish and Wildlife program. William R. Wilkerson, Deputy Director of Washington Department of Fisheries was selected co-chairperson for anadromous fish, while Wendell Oliver, Program Manager, Washington Department of Game, was selected co-chairperson for wildlife and resident fish.

The AEC was charged with evaluating and establishing overall goals and objectives for Fish and Wildlife Program recommendations, as well as providing review and guidance for other aspects of the recommendations. The AEC also provided a forum for the discussion of input from the general public and power entities.

Within the framework of the AEC, specific technical responsibilities were assigned to individual agencies. The Fish and Wildlife Service was designated lead agency staff for resident fish and wildlife responsibilities and the National Marine Fisheries Service was designated lead agency staff for anadromous fish responsibilities.

In developing these recommendations for anadromous fish, the first step was the establishment of overall objectives. On July 27, 1981, a proposed goal, objectives, and subobjectives were formally endorsed by all AEC members, including the Washington Departments of Fisheries and Game, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, National Marine Fisheries Service, Fish and Wildlife Service, and the Columbia River Inter-tribal Fish Commission (representing the Fish and Wildlife Committees of the Umatilla, Nez Perce, Yakima, and Warm Springs tribes). Other regional tribes as well as Montana Department of Fish, Game, and Parks were provided with copies of the proposed goal, objectives, and subobjectives

After the establishment of the goal, objectives, and subobjectives by the AEC, tasks required to fulfill the objectives and subobjectives were developed with agency and tribal review. Each task was assigned to a particular agency or staff member for explanation and supporting discussion. Thus, the anadromous fish recommendations reflect a logical progression from a general goal and overall objectives to meet current fishery problems to specific subobjectives and detailed tasks based on available research.

General and specific recommendations for anadromous fish were subject to vote by the AEC on November 12, 1981. The goal, objectives, and subobjectives for anadromous fish have been endorsed unanimously by participating agencies and tribes. However, there was not always agreement within the AEC on the best methods for achieving the objectives and subobjectives at the task level. Consequently, specific tasks may be endorsed by some agencies and tribes but not by others. In these cases, both a majority and minority position have been reflected in these recommendations.

Coordination with Other Parties

Within the time constraints imposed on the development of these recommendations, the agencies and tribes have attempted to inform interested groups and members of the public as to the fish and wildlife goal, objectives, and subobjectives. First, agency and tribal representatives have attended numerous meetings with interested groups in order to discuss the fish and wildlife provisions of the Power Act, current fish and wildlife problems, and efforts to improve these problems through fish and wildlife recommendations under the Power Act.

Second, both the Washington Department of Fisheries and National Marine Fisheries Service have sent copies of the AEC goal, objectives and subobjectives, along with a narrative explanation, to a number of interested parties for review and comment. The purpose of this effort was to inform interested members of the public who were not currently involved in the work of the agencies and tribes of new efforts to protect, mitigate, and enhance fish and wildlife under the Power Act.

The agencies and tribes were also urged by the Regional Power Council to coordinate with utilities and other power interests in formulating fish and wildlife recommendations. To this end, meetings and discussions have been held with the Bonneville Power Administration, the Corps of Engineers, Direct Service Industry representives, the PNUCC Fish and Wildlife Committee, and the PNUCC Anadromous Fish Subcommittee. Meetings were held with the U.S. Forest Service and Bureau of Land Management. Much of the discussion with the utilities and other agencies has focused on the goal, objectives, and subobjectives.

Finally, at the request of the Regional Power Council, a written status report was submitted on September 11, 1981, and presented at the Council's October 7, 1981 meeting. The status report and presentation included the AEC goal, objectives, and subobjectives and a brief explanation of their intended coverage. Comments and guidance from the Council were also solicited.

All comments received in response to the preceding requests have been given full consideration in the development of these recommendations. The fishery agencies and tribes expect to continue coordination with other parties as the Fish and Wildlife Program is developed and implemented.

CHAPTER B

Inadequacy of Past Efforts to Protect, Mitigate, and Enhance Anadromous Fishery Resources.

CHAPTER B
INADEQUACY OF PAST EFFORTS TO PROTECT, MITIGATE, AND ENHANCE ANADROMOUS FISHERY RESOURCES

Overview

No independent observer can contend that salmon and steelhead runs have received adequate protection, mitigation, and enhancement over the years. The statistics of fishery decline present dramatic evidence that our legal, political, and regulatory institutions have failed to effectively address the dominance of power and the conflict between power and fish production in the use of water resources. Yet, statistics alone do not reveal the full dimensions of the problem--any commercial, recreational, or Indian fisherman will attest to the precarious condition of remaining upriver runs, the demise of other runs, the devastation of valuable fisheries, and related economic and social consequences.

Numerous reports and articles have chronicled and analyzed the second-class status of anadromous fishery resources and the bleak outlook for their survival if current conditions persist. Excerpts from selected reports and articles can help to put the current institutional problems into perspective.

In A Question of Balance (1979), Mr. Ed Chaney of the Northwest Resources Information Center describes the general institutional problems in protecting fishery resources:

> Salmon and steelhead and the people who depended on them traditionally received little or no consideration. Indeed, in most cases, early laws either implicitly or explicitly forbade worrying about salmon or steelhead in water development and use. The philosophy still persists in and exerts a powerful influence upon many current political attitudes and philosophies throughout the Columbia Basin. (Page 3)

* * * * *

> Federal water projects, however, sometimes have failed to provide implied or promised compensation for fishery losses at their dams. This is due in part to the rather wishy-washy provisions of the Fish and Wildlife Coordination Act and the vagaries of the federal funding process. Other factors include lack of information on and/or disagreement over the extent or existence of fishery losses, and lack of initiative by and/or political support for fishery interests. (Page 5).

In a report entitled "Impacts and Implications of the Pacific Northwest Power Bill," (1979) the U.S. General Accounting Office is more specific:

> While other factors such as over-fishing, logging, and industrial development have contributed to the decline of Columbia and Snake River salmon and steelhead runs, a major factor is failure to adequately mitigate the cumulative adverse effects of dams constructed and operated by Federal agencies and electric utilities. (Page 20).

* * * * *

> In the absence of a legislated right to schedule river flows during the spring migration, regional fishery interests are forced to appeal for help in below-average water years. (Page 23)

The GAO went on to recommend turbine screens and bypass systems for all mainstem dams, an anadromous fish council, and the formal establishment of minimum stream flows for the mainstem Columbia and Snake rivers.

In "Hydropower vs Salmon," 11 Environmental Laws 211 (1981), Professor Michael Blumm emphasized that the current institutional problems are political or philosophical rather than legal in nature:

> Several judicial and administrative interpretations of the discretion afforded federal water managers demonstrate that sufficient authority already exists to manage the basin's dams to minimize effects on fisheries. Enactment of statutes such as the Fish and Wildlife Coordination Act and the National Environmental Policy Act considerably narrows the administrative discretion of federal water managers. Their failure to make fisheries protection a fundamental objective of Federal Columbia River Power System (FCRPS) operations is arguably a violation of federal law. The series of contractual agreements often used to support the system's bias toward power maximization hardly justifies the transformation of multiple-use objectives into dominant-use management. (Page 249).

To summarize these and other analyses, anadromous fisheries have been accorded little institutional or legal clout in the competition for water use. Even where protection of fisheries has been legally mandated, institutional disregard has generally favored power generation over fish production.

The Fish and Wildlife Coordination Act

Much of the decline of anadromous fish runs can be attributed to the failure of federal development agencies to take action under the authority of the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661 et seq. Although the law reflects the best of intentions for fish and wildlife, the discretion to protect and enhance fisheries under the Coordination Act not been successfully translated into active maintenance and improvement of salmon and steelhead runs. Since the passage of the Coordination Act, upriver runs have continued to decline.

The purposes of the Fish and Wildlife Coordination Act are to recognize "the vital contribution of our wildlife resources to the Nation and the increasing public interest and significance thereof due to expansion of our national economy and other factors," and, more importantly:

> "to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water resource development programs."

The Coordination Act applies to any major federal or federally licensed water resources project, including federal dams and hydroelectric projects licensed by the Federal Energy Regulatory Commission. Whenever such a project is proposed or authorized, the federal development agency must first consult with federal and state fish and wildlife agencies "with a view to the conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development." The Act is not only intended to protect fish and wildlife resources, but also to enhance or improve them.

Consultation under the Coordination Act concludes with the submission of a report ~~on~~ or recommendations by fish and wildlife agencies to the federal development agency. The federal development agency must give "full consideration" to these reports and recommendations and must include "such justifiable means and measures for wildlife purposes as the development agency finds should be adopted to obtain maximum overall project benefits." Once means and measures to protect and enhance fish and wildlife resources are adopted by the federal development agency, "the cost of planning for and construction or installation and maintenance of such means and measures...shall constitute an integral part of the cost of such projects." In short, the Coordination Act requires "consideration" of fishery impacts and needs and provides discretionary authority to fund protection and enhancement measures, but leaves the ultimate decision on these matters to the federal development agency.

Despite the loose language of the Fish and Wildlife Coordination Act, the legislative history of the Act evidences an optimistic Congressional intent. After noting the "exceptionally enthusiastic and wide spread support" bestowed upon the bill (S. Rpt. No. 1981, 85th Cong., 2d Sess. (1958), U.S. Code Cong. and Admin. News at 3447), the Senate Commerce Committee Report stated: "Adequate provisions must be made for the conservation and preservation of fish and wildlife in our water program if we are to continue to have them as part of our economy and way of life." Id. at 3448-49. Outlining several deficiencies that the new Act was designed to address the Committee Report stressed:

> The amendments proposed by this bill would. . . have several other important advantages. The amendments would provide that wildlife conservation shall receive equal consideration with other features in the planning of federal water resource development programs. This would have the effect of putting fish and wildlife on the basis of equality with flood control, irrigation, navigation, and hydro-electric power in our water resource programs, which is highly desirable and proper, and represents an objective long sought by conservatonists of the nation. [Emphasis added, Id. at 3438]

Unfortunately, the promise of the Fish and Wildlife Coordination Act has not been realized, and means and measures to protect and enhance anadromous fisheries in the Columbia River Basin have usually been too little and too late*. Over the years, the contrast between the intent of the Act,

*This problem is not limited to anadromous fisheries. The failures of the Fish and Wildlife Coordination Act have been well-documented in a report by the General Accounting Office entitled "Improved Efforts to Equally Consider Wildlife Conservation with Other Features of Water Resources Development" (1974) and in 1974 and 1978 oversight hearings. On the other hand positive efforts under the Coordination Act include the Lower Snake Compensation Plan, the installation of spillway deflectors, and the initiation of screening and transportation at Corps dams, but these are only partial efforts.

the letter of the Act, and actual practice by federal development agencies has lead to cases of litigation.

A landmark case in litigation under the Fish and Wildlife Coordination Act is Udall v. Federal Power Commission, 387 U.S. 428 (1968). In the Udall case, the Secretary of the Interior challenged the Commission's decision to approve the High Mountain Sheep Hydroelectric Project despite recognized damage to anadromous fish runs. Citing the Fish and Wildlife Coordination Act, (in combination with the Anadromous Fish Conservation Act and the Federal Power Act), the U.S. Supreme Court agreed with the Secretary of Interior and remanded the case for further consideration by the Commission. In so doing, the Court first emphasized the value of anadromous fish resources:

> The importance of salmon and steelhead in our outdoor life as well as in commerce is so great that there certainly comes a time when their destruction might necessitate a halt in so-called "improvement" or "development" of waterways. The destruction of anadromous fish in our western waters is so notorious that we cannot believe that Congress through the present Act authorized their ultimate demise. [Id. at 437-38].

The Court went on to specify how anadromous fish concerns must be evaluated, particularly noting the relationship between anadromous fish and available energy alternatives. [Id. at 444]. In summary, the Court states:

> The grant of authority to the Commission to alienate federal water resources does not, of course, turn simply on whether the project will be beneficial to the licensee. Nor is the test solely whether the region will be able to use the additional power. The test is whether the project will be in the public interest. And that determination can be made only after an exploration of all issues relevant to the 'public

> interest,' including future power demands and supply, alternate sources of power, the public interest in preserving reaches of wild rivers and wilderness areas, the preservation of anadromous fish for commercial and recreational purposes, and the protection of wildlife. [(Id. at 450)].

Following the Supreme Court remand, the High Mountain Sheep Project was never constructed.

The Udall decision could have marked a turning point in fisheries protection; the decision could have provided new strength and emphasis for Fish and Wildlife Coordination Act authorities. As with the Act itself, however, the potential implicit in the Court's decision has not been realized. Beyond the actual effect on the High Mountain Sheep Project, there has been little spillover effect or improvement in the overall treatment of anadromous fisheries.

In the wake of Udall, litigation under the Fish and Wildlife Coordination Act has continued. For example, in 1976, the Washington Departments of Fisheries and Game and the Northwest Steelheaders challenged the failure of the Corps of Engineers to satisfy the requirements of the Coordination Act with respect to their Snake River hydroelectric projects [(Northwest Steelheaders et al. v. Alexander), Civil No. 3362 (E.D. Wash. 1977)]. On September 30, 1977, the Court ordered the Corps of Engineers to develop a supplemental fish and wildlife enhancement plan. The matter remains in dispute, since the State has challenged the adequacy of the plan prepared by the Corps of Engineers in response to the Court directive.

More recently, the Fish and Wildlife Coordination Act has provided a basis for petitions to the Federal Energy Regulatory Commission concerning operations of the Mid-Columbia hydroelectric projects. Petitions filed by the Washington Departments of Fisheries and Game, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, the Yakima Indian Nation, the Umatilla Tribe, and the Colville Tribe in the mid-to-late 1970's have alleged damage to valuable spawning and rearing habitat, significant

mortalities to juvenile downstream migrants caused by the construction and operation of the public utility district dams, and a corresponding lack of measures to mitigate and compensate for fishery losses. Based on the petitions, the project licensees and the petitioners have negotiated two interim Settlement Agreements. In 1981, disagreements between the licensees and petitioners arose over the applicability of and compliance with these Agreements, and their future is clouded. Long-term solutions to Mid-Columbia fishery problems under the Fish and Wildlife Coodination Act have been subject to continual delay and little progress.

Agency Requests for Flows and Spill

Under the auspices of the Fish and Wildlife Coordination Act, fishery agencies also make annual requests for fish flows and spill during the spring migration period, when juvenile fish are attempting to reach their ocean habitat. The ability to attain necessary flows and spill, however, has been secondary to power generation requirements. Efforts are therefore infrequently successful.

The recent environmental impact statement (EIS) prepared on The Role of the Bonneville Power Administration in the Pacific Northwest Power Supply System (1981) also demonstrates difficulties in obtaining fishery requests. The draft EIS discussed the "one-utility" concept for Northwest power operations and the "hydro-thermal power system" (using thermal base and hydro peaking power). In extensive comments on the draft EIS (June 12, 1980), the National Marine Fisheries Service noted the absence of meaningful discussion of anadromous fishery impacts, worst case analyses for fish, mitigation proposals, and consideration of less damaging alternatives. The final EIS, released after the passage of the Power Act on January 21, 1981, made little attempt to accommodate the National Marine Fisheries Service's comments, stating with respect to fisheries that "since no programs are proposed, no conflicts are expected." Moreover, in responding to National Marine Fisheries Service's comments, Bonneville Power Administration contended that the Fish and Wildlife Coordination Act did not apply to the Bonneville Power Administration's power planning and coordination functions, despite their impact on the operation and use of water resources.

These are just some examples of past problems in attempting to address protection, mitigation, and enhancement of fishery resources. What the examples demonstrate is the need for a precise, unequivocal legal mechanism to reorder institutional priorities.

The Endangered Species Act

In recent years, concern for declining runs of salmon and steelhead in the upper Columbia and Snake Rivers led fishery interests to propose extraordinary remedies. On October 3, 1978, the National Marine Fisheries Service and the Fish and Wildlife Service published a Federal Register Notice [(43 Fed. Reg. 45628)] which announced the initiation of a biological status review for upriver populations of anadromous fish. The purpose of the review was to determine whether any populations should be proposed for listing under the Endangered Species Act, 16 U.S.C § 1531 et seq.

In furtherance of this review, the two federal agencies began compiling information on the causes of population decline based on the requirements of the Endangered Species Act. The factors recognized by the Act as a basis for listing a species include habitat destruction and degradation, overutilization, disease and predation, inadequate regulatory mechanisms, and ongoing conservation efforts.

The significant contribution of hydroelectric development to the decline of these anadromous fish stocks is well documented. Habitat destruction and degradation, particularly in migration routes, were recognized as clear causal factor in the decline of upriver runs. This problem has been compounded by the inadequacy and unresponsiveness of existing regulatory mechanisms (such as the Fish and Wildlife Coordination Act) to address habitat protection and other methods of restoring and rebuilding fisheries production throughout the Columbia Basin.

The Endangered Species Act is a law of last resort. If salmon and steelhead runs were listed as threatened or endangered species, all federal agencies would be required to use their authorities in furtherance of species conservation and would be prohibited from pursuing actions which could

jeopardize the continued existence of the species. Additionally, if a run were listed as an endangered species rather than a threatened species, "taking" those fish by any means would be unlawful. In view of the potentially severe consequences of the Endangered Species Act, the National Marine Fisheries Service and the Fish and Wildlife Service proceeded cautiously in their Endangered Species Act biological review.*

With the passage of the Power Act and its comprehensive fishery authorities, as well as other recent legal development which focus on improving the conditions of anadromous fish in the Columbia Basin and the Northwest, the Endangered Species Act review may no longer be necessary. Because the Endangered Species Act review is premised on "the inadequacy of existing regulatory mechanisms," the new mechanisms provided under the Power Act must now be considered. Accordingly, the National Marine Fisheries Service and the Fish and Wildlife Service are contemplating a suspension of the Endangered Species Act review pending efforts under the Power Act and other authorities. If these new efforts prove successful, then the Endangered Species Act review would not be resumed. On the other hand, if these efforts provoke the same response as the Fish and Wildlife Coordination Act, then resumption of the Endangered Species Act review might be mandated as the ultimate mechanism to conserve the region's salmon and steelhead runs.

The Power Act Remedy

The Pacific Northwest Electric Power Planning and Conservation Act clearly recognizes that institutional and legal impediments have contributed to the decline of anadromous fish resources in the Northwest.** The House Commerce Committee describes the problem in the following manner:

*See Bodi, "Protecting Columbia River Salmon Under the Endangered Species Act", 10 Environmental Law 149 (1980).

**Similar concerns for anadromous fisheries have been evidenced in the Salmon and Steelhead Enhancement Act of 1980, 16 U.S.C. § 3301 et seq.

Many of the witnesses at the Sub-Committee's regional hearings complained that fish and wildlife resources and their protectors are ignored or treated with disdain by the power interests of the region. Fish and wildlife mitigation and enhancement is not mentioned as an authorized purpose of the federal dams. The fish and wildlife have no vested rights. Fish hatcheries, to compensate for fish losses, have been built but this has not been enough. Efforts to maintain flows for anadromous fish runs have often reportedly met resistance. The GAO points out that BPA, for example, recognizes 'the cost of revenue lost as a result of special operations, including water spillage at federal dams to facilitate downstream movement of juvenile salmon and steelhead during the spring.'

One critic of the Pacific Northwest power interests testified that he feels that these interests take the view that all unappropriated water in the mainstem Columbia and lower Snake River should be used to maximize power production and revenues.
[Emphasis added; H. Rept. No. 96-976, Part I, 96th Cong. 2d Sess. at 46 (1980)]

* * * * *

Existing federal legislation is not adequate to offset the cumulative impact of the hydroelectric dams of the Columbia and its tributaries on fish and wildlife.
[Id. at 48.]

The Commerce Committee goes on to explain that the fishery provisions of the Power Act are intended to remedy these problems, to overcome current legal and institutional impediments to the protection, mitigation, and enhancement of anadromous fish resources. In keeping with this objective Committee Chairman, Dingell stated "It is clearly intended that no longer will fish and wildlife be given a secondary status by the Bonneville Power Administration." [Cong. Rec. H10681, November 17, 1980]

Even with a new fisheries mandate embodied in law, the Congress was not naive about the difficulties which might be experienced in effecting institutional change:

> The Committee recognizes that federal agencies and others in the region cannot correct past mistakes merely by enacting a new law. While many such mistakes unfortunately may be uncorrectable, others can be corrected or avoided. Money, a reasonable amount of time, clear regulatory authority and cooperative participation by the various interests will be needed to protect and rejuvenate the fish and wildlife resources of this region. It is not the committee's intention to make fish and wildlife superior to power or to other recognized needs, but it is the intention of the committee to treat fish and wildlife as a co-equal partner with other uses in the management and operation of hydro projects of the region. [H. Rept. No. 96-976, Part I, 96th Cong. 2d Sess. at 49 (1980)]

The fishery agencies and tribes are also realistic in their views. They do not expect institutional change to occur overnight. Nevertheless, fishery improvements and a new receptivity to fishery problems must be promptly implemented by public and private utilities, federal water managers, the Federal Energy Regulatory Commission, and the Bonneville Power Administration. Otherwise, the Power Act fishery purposes will meet the

same fate as the Fish and Wildlife Coordination Act, and upriver fish runs may not survive the consequences.

CHAPTER C

Power Act Mandate

CHAPTER C
THE POWER ACT MANDATE TO PROTECT, MITIGATE, AND ENHANCE ANADROMOUS FISHERY RESOURCES

Fish and Wildlife Purposes

The Pacific Northwest Electric Power Planning and Conservation Act (the Power Act) recognizes the unique relationship between the production of electric power and the production of anadromous fish in the Columbia River Basin. Along with various power-related objectives, the purposes of the Act include the following:

> to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, of the Columbia River and its tributaries, particularly anadromous fish. [Sec. 2(6).]

The unprecedented inclusion of anadromous fish protections as an integral part of power legislation was based on Congressional findings that anadromous fish "are of significant importance to the social and economic well-being of the Pacific Northwest and the Nation," and are "dependent on suitable environmental conditions substantially obtainable from the management and operation of the federal Columbia River power system and other power generating facilities on the Columbia River and its tributaries." [Sec. 2(6).] In fact, hydroelectric development has resulted in massive destruction of fish habitat and indigenous salmon and steelhead runs. Moreover, continued hydroelectric operations have reduced remaining runs to the point where some border on extinction. (See Chapter E - History of Fish Runs.) In this regard, Committee Chairman Dingell explains:

> The conservation and enhancement of the great migratory fish and wildlife populations of the Pacific Northwest is something of great concern to the sportsmen and conservationists of this

> nation. These are for the first time a matter of urgent priority under this legislation. They are placed on a par with other purposes for federal facilities in this area. If the fish populations of the Pacific Northwest are to be restored to the sportsmen, the Indians and the commercial fishermen, this is the mechanism which will do it.
> [Cong. Rec. H-10680 (Nov. 17, 1980)].

The Fish and Wildlife Program

In large part, the fish and wildlife purposes of the Act are effectuated through Section 4(h). Section 4(h) requires the Regional Power Council to develop and adopt:

> a program to protect, mitigate, and enhance* fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries. Because of the unique history and opportunities present by the development and operation of hydroelectric facilities on the Columbia River and its tributaries, the program, to the greatest extent possible, shall be designed to deal with that river and its tributaries as a system.
> [Sec. 4(h)(1)(A).]

*The terms "protect, mitigate, and enhance" are not defined in the Power Act. The House Commerce Committee Report notes that the absence of definition was deliberate. The Committee omitted a definition for two reasons. First, the terms are not new to those concerned with the resource and, second, a definition might later prove more limiting that anticipated. Nevertheless, the Act does clarify that "enhancement" should be viewed as a means of achieving offsite protection and mitigation as compensation for power-related losses to fish and wildlife. [Sec. 4(h)(8)].

The Fish and Wildlife Program was invested with some urgency in view of the declining condition of anadromous fish runs. The Regional Power Council was required to request fish and wildlife recommendations "promptly" after its establishment, and is further required to adopt a comprehensive Fish and Wildlife Program within one year of the receipt of recommendations.

The core concept of the Fish and Wildlife Program is balance; the Program must "protect, mitigate, and enhance fish and wildlife affected by the development, operation, and management of such [power] facilities while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply." [Sec. 4(h)(5).] The concept of balance, including equal treatment of fisheries, is reiterated in the report of the House Commerce Committee:

> It is not the Committee's intention to make fish and wildlife superior to power or other recognized uses, but it is the intention of the Committee to treat fish and wildlife as a co-equal partner with other uses in the management and operation of hydro projects of the region.
> [H. Rept. No. 96-976, Part I 96th Cong. 2d Sess. at 49 (1980)]

> Section 4(h) is designed to provide effective procedures and authorities whereby fish and wildlife of the Columbia River Basin will be treated on a par with power needs and the other purposes for which the hydroelectric dams of the regions were built and/or operated and maintained. This should insure a balance for all uses of the river.
> [H. Rept. No. 96-976 Part I 96th Cong. 2d Sess at 56 (1980)]

The Power Act and its legislative history clearly indicate that fish and power production have not been balanced in the past, but rather, that power considerations have been dominant. Therefore, the balance to be struck in the Fish and Wildlife Program must represent an improvement in the status quo, an improvement in the treatment and condition of anadromous fish runs. The Act clearly contemplates that reasonable power losses and monetary costs may be inevitable in order to protect, mitigate, and enhance fish and wildlife.

Fish and Wildlife Program Contents

The Power Act contains numerous specifications for the Fish and Wildlife Program. First, the Act outlines a format for the Program:

-- measures to protect, mitigate, and enhance fish and wildlife including related spawning grounds and habitat, affected by the development and operation of hydroelectric facilities.

-- objectives for the development and operation of such projects in a manner designed to protect, mitigate, and enhance fish and wildlife.

-- management coordination and research (including funding) to assist protection, mitigation, and enhancement of anadromous fish at, and between, the region's hydroelectric dams. [Sec. 4(h)(2).]

Within this format, the Fish and Wildlife Program must include measures which will complement existing and future activities of fish and wildlife agencies and tribes; be based on and supported by the best available scientific knowledge; and where equally effective alternative means of achieving the same sound biological objective exist, utilize the alternative with the minimum ecnomic cost. [Sec. 4(h)(6)(A)-(C).]

Two additional requirements for the Fish and Wildlife Program underscore the particular significance of measures for anadromous fish. First, the program must be consistent with the legal rights of Indian tribes in the

region, particularly rights interpreted in the United States v. Washington series of decisions. (See Chapter D - Indian Treaty Obligations) Second, the program must provide for "improved survival of anadromous fish at hydroelectric facilities" and "provide flows of sufficient quality and quantity between such facilities to improve production, migration, and survival of anadromous fish." [Sec. 4(h)(6)(D)-(E).] Thus, within the "balance" between fish and power production, the Regional Power Council must assure that Indian treaty rights to protection, mitigation, and enhancement of salmon and steelhead trout runs are fully accommodated, and similarly, that the condition of these runs will be bettered through improved passage and improved flow regimes.

Recommendations for the Fish and Wildlife Program are expected to be both comprehensive and innovative. In this regard, the House Commerce Committee states:

> The recommendations are clearly required to include, as appropriate, a broad range of measures which could for example be regulatory or management type to "protect, mitigate and enhance" fish and wildlife and their spawning grounds and habitat. The objective is give flexibility to all concerned to devise effective and imaginative measures that are also reasonable...
> [H. Rept. No. 96-976, 96th Cong. 2d Sess. at 57 (1980)]

More particularly, the House Interior Committee encourages fish and wildlife agencies to recommend fish passage mechanisms other than spill:

> It is anticipated that because of the importance of non-firm power sales outside the Pacific Northwest and the opportunity value of such sales, at least some of these recommendations will explore alternative methods by which fish migration can be

improved without unnecessasry spillage of water.
[H. Rept. No. 96-976, Part II, 96th Cong. 2d Sess. at 44 (1980)]

The primary alternative to spill for fish passage is juvenile bypass systems. (See Chapter 1.)

Program Procedures

The Power Act also specifies a procedural framework and standards for formulation and adoption of the Fish and Wildlife Program by the Regional Power Council. First, the Council must call for detailed recommendations from fish and wildlife agencies and Indian tribes (a step taken by the Council on June 10, 1981). Recommendations may also be submitted by the public, including water management agencies, electric utilities, and utility customers. [Sec. 4(h)(3).]

Once the recommendations are received, the Council must provide for public participation and comment. Notice of all recommendations must be given to the public in general, and to the Bonneville Power Administration, fish and wildlife agencies, Indian tribes, the Corps of Engineers, the Bureau of Reclamation, and the Federal Energy Regulatory Commission in particular. At a minimum, the Council must provide the public an opportunity for written and oral comment. [Sec. 4(h)(4).]

The Fish and Wildlife Program must be developed by the Regional Power Council based on the record of recommendations and public comment, in consultation with the fish and wildlife agencies, tribes and power customers. [Sec. 4(h)(5).] For each recommendation submitted, the Council must determine consistency with the Act. Recommendations may only be rejected by the Council upon written findings that the recommendation is inconsistent with the "balance" concept described above, inconsistent with the requirements for program contents described above, or less effective than the adopted recommendation for the protection, mitigation, and enhancement of

fish and wildlife. Other grounds for rejection are not available to the Council.

With respect to the last grounds for rejection--the relative effectiveness of differing recommendations on meeting fish and wildlife needs--the Power Act recognizes that inconsistent recommendations may be made to the Regional Power Council. In such a event, the Council must resolve the inconsistencies or choose between the recommendations, giving due weight to the recommendations, expertise, and legal rights and responsibilities of the Federal and State fish and wildlife agencies and Indian tribes. [Sec. 4(h)(7).] In case of conflict, this means that the Council must grant particular deference to the views and recommendations of the fish and wildlife agencies and Indian tribes.

Implementation of the Fish and Wildlife Program

Once the Regional Power Council adopts the Program, fish and wildlife measures must be translated into effective action. To this end, the Power Act imposes specific implementation requirements on Federal agencies responsible for hydroelectric operations and fish and wildlife impacts.

First, the Bonneville Power Administration must use the BPA fund and the authorities available to the Administrator to protect, mitigate, and enhance fish and wildlife "in a manner consistent with" the Fish and Wildlife Program. [Sec. 4(h)(10).]

Further, the Administrator and "other Federal agencies responsible for managing, operating, or regulating Federal or non-Federal hydroelectric facilities" must exercise their responsibilities "taking into account at each relevant stage of decisionmaking to the fullest extent practicable the program adopted by the Council," -- an evaluation which should be made in writing. The same agencies must consult with fish and wildlife agencies and Indian tribes in carrying out their responsibilities to implement the program, and must "to the greatest extent practicable, coordinate their actions." [Sec. 4(h)(11).]

Accordingly, Federal agencies such as the Corps of Engineers and the Bureau of Reclamation are directly bound to act on the Fish and Wildlife Program, while non-federal hydroelectric operators will be bound indirectly through action by the Federal Energy Regulatory Commission. Even though the Power Act does not require absolute consistency with the Fish and Wildlife Program by Federal water management and regulatory agencies, the Act's standards impose a heavy burden of proof if the agency proposes to reject a program measure. Any determination by a federal agency to reject a program measure must be made in writing and must fully explain the basis for the determination.

In addition to the federal agency obligation to take the Fish and Wildlife Program into account to the fullest extent practicable, the Power Act imposes a new substantive standards on all power system planning, management, development, and operations. Federal agencies responsible for hydroelectric projects such as Bonneville Power Administration, Federal Energy Regulatory Commission, Bureau of Reclamation, and the Corps of Engineers must

> exercise such responsibilities consistent with the purposes of this Act, and other applicable laws, to adequately protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by such projects or facilities in a manner that provides equitable treatment for such fish and wildlife with the other purpose for which such system and facilities are managed and operated. [(Sec. 4(h)(11)(A).]

The "equitable treatment" standard is a significant improvement in current mechanisms for fish and wildlife protection under the Fish and Wildlife Coordination Act, and was recognized as such in the passage of the Power Act. According to the House Commerce Committee, this standard supplements other provisions of law, and is "aimed at placing fish and wildlife on a par with" power production and other project purposes. The equitable treatment standard buttresses the comprehensive Fish and Wildlife Program requirements under Section 4(h) of the Act.

It is self-evident that there will be power losses and monetary costs associated with implementation of the Fish and Wildlife Program. Fish and wildlife costs attributable to development and operation of power facilities will be borne by consumers of electric power, with costs and power losses allocated by the Bonneville Power Administration "consistent with individual project impacts and system-wide objectives." [Sec. 4(h)(8).] System-wide costs and losses are to be borne by the Bonneville Power Administration. [Sec. 4(h)(11).]

Implementation of the Fish and Wildlife Program must be monitored by the Regional Power Council. In its annual report to Congress, the Council must include an evaluation of the effectiveness of the Fish and Wildlife Program and potential revisions or modifications to the program as needed. The fish and wildlife agencies and tribes must be afforded an opportunity to review this report 90 days prior to its submission, and their comments must be appended to the report.

Revisions or modifications to the Fish and Wildlife Program will certainly prove necessary. Revisions or modifications may be initiated by either the Regional Power Council or fish and wildlife interests and presumably would follow procedures similar to those for initial program development.

Selected Power Act Issues

- "Detailed Information and Data in Support of the Recommendations;"
  "Based on, and Supported by, Best Available Scientific Knowledge"

The Power Act establishes supporting information requirements both for the recommendations submitted to the Council and for the Council's adoption of Fish and Wildlife Program measures. With respect to the recommendations, Sec. 4(h)(3) specifies that "All recommendations shall be accompanied by detailed information and data in support of the recommendations." All recommendations submitted to the Council whether by fish and wildlife agencies or other parties, must include explanatory materials and citations to supporting scientific and other data. Turning to the actual Fish and Wildlife Program, Sec. 4(h)(6) states that the Council must adopt measures which will

"be based on, and supported by, the best available scientific knowledge." "Knowledge" must be interpreted to include scientific research data, general understandings inferred from such data, and scientific viewpoints based on biological observations and experience.

The House Commerce Committee explains the Act's "data," "information," and "knowledge" requirements in the following manner:

> The recommendations must be accompanied by data to support them. The better the data, the more likely it is that the recommendations will receive wide support. While the Committee believes it reasonable to expect organizations with fish and wildlife expertise to be able easily to provide needed support data, the Committee also recognizes, and the Council should also, that ninety days will not afford an opportunity for extensive studies the acquisition of new data, or the development of best available scientific knowledge. The data requirement is to enable the Council and others to understand the recommendations. The quantity or quality of the data should not serve as a basis for turning down any recommendation.
> [(Emphasis added, H. Rept. at No. 96-976, Part I, 96th Cong. 2d Sess. at 56 (1980.)]

In other words, the information requirements set out in Sections 4(h)(3) and 4(h)(6) are intended as a rationale, to provide a basis for understanding the fish and wildlife measures. Recognizing the limitations of scientific data in assessing the complexity of anadromous fisheries, the report explains that the "data," "information," and "knowledge" requirements are not intended as a rigid measure of the sufficiency of fish and wildlife recommendations.

Committee Chairman Dingell's supplemental section-by-section analysis further describes how the Council should use the "best available scientific knowledge" standard:

> For example, it is clear that the criterion that the measures be based on and supported by the best available scientific knowledge requires a certain amount of judgment by the fish and wildlife agencies in determining whether or not the measures meet this kind of test."
> [Cong. Rec., at H.-1068 (Nov. 17, 1980)]

Recognizing that judgment will be involved in applying the "best available scientific knowledge" criterion, this statement reflects an understanding that the Regional Power Council will rely on the agencies with expertise in and responsibility for overseeing fish and wildlife resources, i.e. state and federal fish and wildlife agencies and Indian tribes.

- "Adequate, Efficient, Economical, and Reliable Power Supply"

As described above, the Power Act Fish and Wildlife Program is intended to strike a balance between the protection, mitigation, and enhancement of fishery resources and an adequate, efficient, economical, and reliable power supply. Currently, conditions are not balanced, and power supply considerations dominate . Striking a balance will require a significant improvement in the treatment of anadromous fisheries.

The House Commerce Committee expressly recognizes that power and revenue losses may result from the Fish and Wildlife Program:

> The objective is to give flexibility to all concerned to devise effective and imaginative measures that are also reasonable and will not result in unreasonable power shortage or loss of power revenues. Some power losses with resultant loss of revenues may be inevitable at times if these fish and wildlife objectives

> are to be achieved. Such losses, however, should not be a burden on the consumers of the region. The objective, however, should be to avoid or at least minimize losses while meeting fish and wildlife needs.
> [(Emphasis added. H. Rept. No. 96-976, Part I, 96th Cong. 2d Sess. at 57 (1980).]

Although the Committee indicates that economic considerations must be considered, it explains that "costs should not be a deterrent if a fish and wildlife need might be sacrificed to save dollars." Sec. 4(h)(8)(D) is consistent with this interpretation, recognizing that "monetary costs and electric power losses resulting from the implementation of the program" will have to be allocated among hydroelectric facilities.

Despite Congressional recognition that increased power losses and monetary costs will result from the Fish and Wildlife Program, it would be naive to expect that such losses and costs will be readily accepted by utilities, power managers, and customers. Nevertheless, the Power Planning Council's obligation, and the ultimate obligation of these groups, is to accommodate and accept responsibility for reasonable fishery needs within the power system. Arguments against reasonable power losses and costs can only be based on the faulty assumption that the rivers are set aside for power production, and that fisheries do not have an equally strong and valid right to water use. Under the current system, power production is exacting unreasonable losses and monetary costs to fish runs and fisheries.

- "Utilize, Where Equally Effective Alternative Means of Achieving the Same Sound Biological Objective Exist, the Alternative With the Minimum Economic Cost."

Under Section 4(h)(6) of the Power Act, program measures adopted by the Council must "utilize, where equally effective alternative means of achieving the same sound biological exist, the alternative with the minimum economic cost." In other words, if two equally effective means exist to do

the job, the less expensive measure should be selected. This criterion is certainly logical and almost platitudinous. However, the standard may be subject to further examination if questions arise concerning "equally effective" alternatives to meet biological objectives.

Neither the Act nor its legislative history shed further light on the "equally effective alternative" criterion. However, some consensus on the criterion was achieved by the Ad-Hoc Pacific Northwest Power/Fish Committee. While this consensus does not have the status of statutory language or legislative history, it is useful as a contemporaneous understanding of both power and fishery interests. In a section-by-section analysis dated August 14, 1980, the Ad-Hoc Committee stated:

> The third criterion on this subparagraph is intended to indicate that in those instances where alternative means of achieving the same sound biological objective exist, the alternative with the minimum economic cost should be undertaken. For example, if either of two bypass systems will pass juvenile anadromous fish over a particular dam, the lower cost system should be selected. However, a lower cost system would not be selected under this criterion if it were significantly less effective in meeting the biological objective (e.g., passage of the fish). The evaluation of alternative means of meeting a particular objective, in other words, should not undercut the evaluation of the objectives themselves based on the purposes of this Act. In some cases, no lower cost means of achieving the objective will exist.

2"Consistent With the Legal Rights of Appropriate Indian Tribes"

In addition to the statutory obligations placed upon the Bonneville Power Administration and the Regional Planning Council are the Indian treaty fishing and water rights and the federal government's trust obligations to protect those rights. Indian fishing rights are constitutionally protected property rights which may not be diminished except by the express action of Congress. Federal and state agencies may not abrogate Indian treaty rights or act to diminish tribal resources. Indian treaty fishing rights implicitly include the right to protect the habitat of the fish, since without that right, the fishing right becomes meaningless.

In addition to the treaty fishing right and associated rights to habitat protection, the tribes have reserved water rights which may be asserted to protect fish throughout their life-cycle. These water rights are prior in time to other water rights in the region, and thus must be satisfied before the rights of later water users.

Complementing these treaty fishing and water rights is the obligation of agencies of the federal government to preserve, protect, and enhance tribal assets. For 150 years, the U.S. Supreme Court has consistently recognized this correlative duty. Analogizing to common law trust principles, the Supreme Court has placed an obligation on federal agencies to protect treaty assets and to use their expertise and skill to make the trust property productive. Most important, the agencies' paramount obligation is to manage the tribal resource solely in the interest of the tribe. Courts consistently have held that an agency can not "balance" tribal interests against the interests of other parties. To make a "judgment call" which does balance tribal interests is an abuse of discretion and not legally permissible. Thus, if an agency's proposed action may affect treaty fishing or water rights, the agency's discretion is limited by its affirmative duty to protect and enhance these tribal resources.

The Power Act reaffirms these general principles. Section 10(e) states that "nothing in this Act shall be construed to affect or modify any treaty or other right of an Indian Tribe." Moreover, the Fish and Wildlife Program must be "consistent with the legal rights of appropriate Indian tribes in the region." [Sec. 4(h) (6)]. These rights, including fishing rights, water

rights, and the right to protect fish habitat are described in detail in Chapter D. Neither the Council nor any agency of the federal government may infringe these rights, but must affirmatively act to protect and enhance tribal assets. The passage of the Power Act reaffirms Congress's recognition of these rights and the federal government's correlative duties.

- "Complement the Existing and Future Activities of the Federal and the Region's State Fish and Wildlife Agencies and Appropriate Indian Tribes"

Section 4(h)(6)(A) of the Power Act requires that the Fish and Wildlife Program contain measures which "complement the existing and future activities of the Federal and the region's state fish and wildlife agencies and appropriate Indian tribes." As in other sections of the Act, this provision accords a substantial degree of deference to these groups based on their existing and future activities. Based on the criterion of Section 4(h)(6)(A), the Fish and Wildlife Program adopted by the Regional Power Council must dovetail with the overall framework for fishery planning and management as established by the agencies and tribes in accordance with their respective legal authorities.

The National Marine Fisheries Service and the Fish and Wildlife Service are the federal agencies responsible for oversight and evaluation of activities that affect fishery resources. This responsibility derives from the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 4321 et seq., and other similar authorities. The two Services are also charged with listing and consultation responsibilities for threatened or endangered fishery resources and their habitat under the Endangered Species Act 16 U.S.C. §§ 1531 et seq. The National Marine Fisheries Service and the Fish and Wildlife Service undertake many activities designed to restore valuable fish runs and provide productive commercial, recreational, and Indian fisheries within the States of Washington, Oregon, and Idaho.

The Washington Department of Fisheries has the duty and purpose to "preserve, protect, perpetuate and manage the food fish and shellfish in the

water of the state..." (RCW 75.08.012). Food fish in the Columbia River include, but are not limited to five species of salmon, and smelt and sturgeon. The Washington Department of Game has jurisdiction over steelhead trout.

Within the State of Oregon, the Oregon Fish and Wildlife Commission and the Oregon Department of Fish and Wildlife have exclusive jurisdiction over all fish within the waters of the state, and have joint jurisdiction over steelhead trout.

Within the State of Idaho, the Idaho Department of Fish and Game, under the supervision and direction of the Idaho Fish and Game Commission, is responsible for enforcement of all laws of the state and rules and regulations relating to fish (36-106 Idaho Code). Fish located within Idaho are considered property of the State and must be preserved, protected, perpetuated, and managed by the State (36-103 Idaho Code).

The region's Indian Tribes have treaty rights to fisheries and their supporting habitat and exercise management authority over their fisheries, as discussed further in Chapter D.

Accordingly, all of the agencies and tribes have legal mandates which must be reflected in both the adoption and implementation of the Fish and Wildlife Program under the Power Act. The state agencies and Indian tribes in particular have extensive responsibilities which must be reflected and recognized in the Program.

Perhaps most significantly, the state agencies and tribes are responsible for fishery management, including establishing and regulating seasons, size and bag limits, area restrictions, gear restrictions, etc. Management of the commercial fisheries of the Columbia River waters is conducted through the Columbia River Compact (RCW 75.40.010, ORS 507.010 and 36-2001 Idaho Code), which is intended to achieve mutually acceptable and identical regulation for commercial fishermen.

In the area of fish hatcheries and propagation, state agencies regulate the taking of fish, dead or alive for inspection, cultivation, propagation, distribution, and transplanting for scientific or other purposes (RCW 75.16.101, 36-104, 106 Idaho Code) except in Oregon where the Fish and Wildlife Service, the agency, and authorized agents may conduct fish cultural operations and scientific investigations in the waters of the state (ORS 506.050). In Idaho, fish racks and traps may be placed only as permitted by the state agency (36-905 Idaho Code).

In every state, fishways must be furnished for passage of anadromous fish at artificial obstructions or dams where necessasry. The fishways must be constructed to criteria approved by the state agency and built and maintained at the expense of the owner of the dam (ORS 509, 605, RCW 75.20.060, and 36-906 Idaho Code). In Oregon and Washington, where a fishway is determined by the director to be impractical, fish hatcheries may be substituted (RCW 75.20.090, ORS 509-640).

Ditches, channels, canals, and waterways used for diverting water from any body of water must be screened to prevent the passage of fish into the diversion (RCW 75.30.050, ORS 509-615, 36-906 Idaho Code). The screens must be constructed and maintained to meet the specifications of the state agency.

Finally, all research which requires the handling and taking of anadromous fish requires a permit or permission from appropriate state agencies and Indian tribes.

CHAPTER D

Indian Treaty Obligations

CHAPTER D

INDIAN TREATY OBLIGATIONS

Columbia Treaty Tribes Existing Legal Rights Supporting Their Section 4(h) Fisheries Recommendations Under the Regional Power Act

Prepared by
The Columbia River Inter-Tribal Fish Commission

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Introduction: Since time immemorial the Columbia River and its tributaries were viewed by the four Columbia treaty tribes--the Umatilla Tribes, the Warm Springs Tribes, the Yakima Indian Nation, and the Nez Perce Tribe--as a great table where all the Indians came to partake. Seufert Brothers Co. v. United States, 249 U.S. 194, 197 (1919). A century and one quarter after the signing of the Stevens treaties, the river still serves as a great table, but more people sit around the table and the Indians' place at the table is subordinated to energy production and other water uses. The treaties--the supreme law of the land under the United States Constitution--promised more. Instead of receiving 50 percent of the allocable fish passing the tribes' usual and accustomed fishing sites, as decreed by the Supreme Court, today the Columbia treaty tribes arduously struggle for a very small fraction of their reserved fishing right.

For the fifth consecutive year, Columbia River runs have been the lowest on record. The Government Account Office (GAO) identified the construction and operation of dams on the Columbia River and its tributaries as a principle cause for the depressed fish runs. U.S. Comptroller General, Impacts and Implications of the Pacific Northwest Power Bill, Rep. No. EMD-79-105 at 22, IV. 1 (1979) [hereinafter cited as 1979 GAO Report]. Fish losses caused by hydroelectric dams and reservoirs are staggering. At each mainstem dam on the Columbia and Snake Rivers an estimated 15 percent of upstream migrants are lost from disorientation and downstream return over the spillways. Report and Supplemental Report of Special Master on the Affirmative Defenses of Oregon and Washington to the Complaint of Idaho 9, in Idaho ex rel. Evans v. Oregon and Washington, 429 U.S. 164 (1976). Mortality rates for downstream migrating smolts is estimated at between 15 and 30 percent at each mainstem

dam. 1979 GAO Report, at 22, IV.2. Virtually all major dams and reservoir complexes in the Columbia River and its tributaries are either owned or licensed by a federal agency. These federal agencies owe a fiduciary duty, judged by the most exacting standards, to protect tribal reserved fish and water rights.

Columbia River treaty tribes reserved the right to fish at all usual and accustomed fishing stations "in common with" the citizens of the territory. This provision is the "cornerstone" of the Stevens treaties. The fishing right means more than the right of Indians to hang a net in an empty river. Washington v. Washington State Commercial Passenger Fishing Vessel Assn, 443 U.S. 658, 679, (1979); United States v. Washington (Phase II) 506 F. Supp 187, 203 (W.D. Wash., 1980). The right to fish includes sufficient water flows and a right to environmental protection of fish habitat. Navigating a gauntlet of hydroelectric generators on the anadromous fisheries' downstream migration and the almost equally perilous return trip destroys not only the fishery habitat; it destroys most of the fish. Existing manipulation of flows in the Columbia Basin to maximize electricity, at the expense of fish, is inimical to Indian treaties and the United States' fiduciary responsibilities.

The Columbia River treaty tribes view the Regional Power Act as an unprecedented opportunity to restore Columbia Basin fish runs and to realign Columbia power system management with the tribes' three major legal rights: (1) the right to fish; (2) reserved Indian water rights; and (3) the trust relationship. These three legal rights combine, synergistically, to require fundamental changes in the operation and management of the Columbia River power system.

The fact that these rights historically have not been vigorously protected should not be construed as a lack of worth in the rights. For example, failure to enforce constitutional rights does not derogate the Constitution's worth; it merely reflects unconstitutional activities. Columbia River treaty tribes have honored their obligations under the Stevens treaties; the United States is legally required to do the same. Great nations like great men should keep their word. Federal Power Commission v. Tuscararo, 262 U.S. 99,142 (1960) (Black, J. dissenting).

The Columbia River treaty tribes' trilogy of core legal rights have not been repealed or modified by any act of Congress. In fact, the Regional Power Act affirms all of these legal rights. Section 10(e) states that "nothing in this Act shall be construed to affect or modify any treaty or other right of an Indian tribe" Additionally, section 4(h)(6)(D) states that: "The Council shall include in the [fisheries] program measures which it determines...will be consistent with the legal rights of appropriate Indian tribes in the region...." Section 4(h)(2) directs the Power Planning Council to request fish and wildlife recommendations from appropriate Indian tribes. If the Power Planning Council is faced with inconsistent recommendations, section 4(h)(7) requires the Council to "resolve such inconsistency in the program giving due weight to the recommendations, expertise, and legal rights...of the...appropriate Indian tribes."

Until Congress acts explicitly, consistent with its obligations as a trustee, to abrogate or modify any aspect of the tribes' reserved rights or fiduciary relationship, all federal agencies and states are constitutionally required to

honor the Indian's legal rights. As pointed out herein, Congress' express intent in the Regional Power Act does not abrogate, rather it reinforces the Indians' existing legal rights.

Then, why did the Columbia treaty tribes work for inclusion of fishery provisions in the Regional Power Act if other legal recourses are available to them? The answer to this rhetorical question is that the tribes view the section 4(h) fisheries program as a more constructive way to implement its legal rights than protracted litigation.

It is essential to understand that existing tribal legal rights supplement the fishery provisions of the Regional Power Act, and are more stringent with respect to protection, mitigation, and enhancement of anadromous fish. For example, a major distinction between recommendations submitted by the Columbia River treaty tribes and recommendations submitted by non-Indian entities is that the substance of the tribes' recommendations can not be balanced with the objective of supplying the region an "adequate, efficient, economical, and reliable power supply." The reason for this is endemic to the nature of tribal reserved rights. In the Stevens treaties the Columbia tribes reserved to themselves certain rights to fish and water. In the 1850's these tribes did not qualify these rights to make them consistent with regional energy efficiency, or the economic convenience of its trustee or the energy companies. In fact, the tribe reserved these rights for the opposite reason -- to protect these aboriginal property interests from non-Indian exploitation. Moreover, the concept of a trustee balancing the beneficiary's interest with its own pecuniary gain is antithetical to established private and Indian trust principles. Under Article Three of the Unites States Constitution, federal courts will not vitiate a federal statute's purpose solely because of economic

factors. Tennessee Valley Authority v. Hill, 437 U.S. 153, 187-88 (1978). Clearly, the federal courts should refuse to vitiate the substance of rights secured by treaties, which stand on a higher plane than do statues.

The legal rights discussed below, in concert with the Regional Power Act, form the legal basis for the Columbia River treaty tribes Section 4(h) recommendations.

The Right to Fish

A. Reserved Fishing Rights

For Columbia River basin Indian tribes, the right to fish is "not much less necessary to the existence of the Indians than the atmosphere they breathed." United States v. Winans, 198 U.S. 371, 381 (1905). In 1855 the United States negotiated separate treaties with four Columbia Basin tribes: The Yakima Tribe, the Warm Springs Tribes, the Umatilla Tribes, and the Nez Perce Tribe. These treaties were ratified and proclaimed by the United States in 1859. Treaty of June 9, 1855 with the Yakima Tribe (12 Stat. 951); Treaty of June 25, 1855 with the Tribes of Middle Oregon (12 Stat. 963); Treaty of June 9, 1855 with the Umatilla Tribes (12 Stat. 945); Treaty of June 11, 1855 with the Nez Perce Tribe (12 Stat. 957). [Hereinafter Stevens treaties]. Each of these treaties contained a substantially identical provision reserving to the tribes "the right of taking fish at all usual and accustomed places in common with citizens of the territory." (Emphasis added) This fishing clause is the "cornerstone" of the Stevens treaties. United States v. Washington, 506 F. Supp. 187, 203 (W.D. Wash. 1980). Under Article Six, C1.2 of the Constitution of the United States treaties constitute the supreme law of the

land. Indian treaties have as much force as any treaty made with any other nation. Worcester v. Georgia, 31 U.S. (6 Pet.) 515, 559 (1832).

A fundamental precept of Indian law is that the Indians were not granted rights in treaties; instead, the Indians reserved to themselves the rights which they already possessed since before non-Indians came to the United States. This legal principal was firmly established by the Supreme Court in its first case interpreting the Stevens treaties. United States v. Winans, 198 U.S. 371 (1905). See also Seufert Bros. Co. v. United States, 249 U.S. 194 (1919), Tulee v. Washington 315 U.S. 68± (1942), Puyallup Tribe v. Washington Department of Game, 391 U.S. 392 (1968), Washington v. Washington Commercial Passenger Fishing Vessel Assn., 99 S. Ct. 3055 (1979). In Winans non-Indian settlers obtained title to lands bordering the Columbia River opposite the Yakima Indian Reservation. The non-Indians stationed a fish wheel on this land--one of the best fishing locations on the river. Though the fish wheel was placed as a "usual and accustomed" Indian fishing site, the non-Indians refused to allow a Yakima Indian access to fish at the site. In a landmark decision, the Supreme Court held that a servatude existed providing a right of access to Yakima tribal members. According to the Court the fact that Mr. Winans owned the land in fee simple and that it was not located within an Indian reservation was inconsequential. The Court likened the Yakima tribe's "immemorial right" to fish to a ripened prescription or a servitude which superseded the non-Indian's fee simple title to the land.

The Winans decision's most significant contribution to Indian law is its articulation of the reserved rights doctrine: "the treaty was not a grant of rights to the Indians, but a grant of rights from them - a reservation of those

not granted." Id. at 381. The Winans reserved rights doctrine is the law today. See e.g. State of Washington v. Washington State Commercial Passenger Fishing Vessel Association, 443 U.S. 658, 678 (1979) (Passenger Fishing Vessel); United States v. Wheeler, 435 U.S. 313, 327 N. 24 (1978).

B. The Nature of the Right

The Columbia River treaty tribes' fishing right is a usufructuary right. That is, it is not a property right in the fish themselves, but instead, is a right to use the resource. See United States v. Michigan, 471 F. Supp. 192, 256 (W.D. Mich. 1979), aff'd, 623 F.2d 448 (6th Cir. 1980); United States v. Washington, 506 F. Supp. 187, 201-2 (W.D. Wash. 1980). The fishing right is a property right of the tribe, not the individual tribal members. Whitefoot v. United States, 293 F.2d 658, 663 (Ct. Cl. 1961), cert. denied 369 U.S. 818 (1962); Kimball v. Callahan, 590 F.2d 768, 773 (9th Cir. 1979), cert. denied 444 U.S. 826 (1979); United States v. Michigan, 471 F. Supp. 192, 271. Columbia River treaty tribes reservied the right to take fish (1) within their respective reservations, See Stevens treaties, supra; (2) at all usual and accustomed fishing sites on lands ceded to the United States government, Tulee v. State of Washington, 315 U.S. 681, 684 (1942); and (3) at all usual and accustomed fishing sites outside the reservation or ceded areas. Seufert Bros. v. United States, 249 U.S. 194, 198-199 (1919). Columbia River treaty tribes likewise "reserved the authority to regulate tribal fishing at all usual and accustomed places, whether on or off the reservation." Settler v. Lameer, 507 F2d 231, 237 (9th Cir. 1974).

In 1969 Sohappy v. Smith, 302 F. Supp. 899 (D.Or. 1969), was commenced in federal district court by certain members of the Yakima Tribe aggainst the Oregon Fish and Oregon Game Commissions. Later, all four Columbia River treaty tribes and the United STates intervened seeking a decree defining the nature of the fishing rights in the Stevens treaties. Judge Belloni rendered his decision that same year: the treaty Indians have "an absolute right" to the fishery and are thus entitled to a "fair share of the fish produced by the Columbia River system" Sohappy, 302 F. Supp. at 911; See also Sohappy vs. Smith Civil No. 68-409 (D. Or. May 8, 1974) (Order Dissolving Temporary Restraining Order). In subsequent proceedings Judge Belloni determined that a "fair share" means a 50-50 division of the fishing opportunity. Sohappy v. Smith, Civil No. 68-409 (D. Or. August 20, 1975) (Preliminary Injunction Order); See also United States v. Oregon, No. 68-513 (D. Or. August 10, 1976) (Temporary Restraining Order). The Ninth Circuit has affirmed the determination that "fair share" means a 50-50 division first articulated by Federal District Judge George Boldt. United States v. Washington, 384 F. Supp. 312 (W.D. Wash, 1974) (Final Decision I), aff'd 520 F.2d 676 (9th Cir. 1975), cert. denied 423 U.S. 1086 (1976); United States vs. Washington, 459 F. Supp. 1020 (W.D. Wash. 1975-1978) (Post Trial Decisions), various appeals dismissed, decisions at 459 F. Supp. 1020, 1097-1118 (W.D. Wash. 1977-78). [Hereinafter the Washington fishery cases mentioned in this paragraph, including Passenger Fishing Vessell, will be collectively referred to as Phase I].

In 1979 the United States Supreme Court endorsed the 50-50 allocation in its opinion in Passenger Fishing Vessel, 443 U.S. 658 (1979). In this opinion the Court stated that the 1974 Boldt decision "has faced the most concerted official and private efforts to frustrate a decree of a federal court witnessed in

this century." Id. at 696 n. 36. Significantly, the Court rejected Washington's "equal opportunity" argument stating:

> In our view, the purpose and language of the treaties are unambiguous; they secure the Indian's right to take a share of each run of fish that passes through tribal fishing areas.

Id. at 679 (emphasis added). The Indian treaty right to 50 percent of harvestable fish runs imposes a maximum but not a minimum allocation, which may be lowered should a lesser amount guarantee the Indians "a moderate living." Id. at 686. The Columbia Basin treaty tribes allocation is currently set at 50 percent. See United States v. Washington, 506 F. Supp. 187, 208 (W.D. Wash. 1980) State of Idaho v. State of Oregon and Washington, ___ U.S. ___, 100 S.Ct. 616, 619 (1980). There is presently a presumption that the moderate living needs are not being met. United States v. Washington 506 F. Supp. at 208. The burden is upon the state to demonstrate to the Phase I court that the tribes' needs may be satisfied by a lesser allocation. Id.

A corollary to Phase I of direct relevance to the Regional Power Act's Sec. 4(h) program is Judge Orrick's recent Phase II opinion. United States v. Washington, 506 F. Supp. 187 (W.D. Wash. 1980). The Phase I right to 50 percent of fish runs passing through usual and accustomed fishing sites is a meaningless right if most of the fish are destroyed by a hostile environment (e.g., the Columbia River Basin hydroelectric system) and other manmade environmental degradation (e.g., thermal pollution). In good faith, tribal ancestors bargained for a more substantive fishing right when they ceded

millions of acres to the United States. Stated simply, Indian tribes bargained for more than the "the right to dip one's net into the water...and bring it out empty." Phase II 506 F. Supp. at 203.

The major question presented in Phase II was whether the right to take fish incorporates the right to have treaty fish protected from environmental degradation. Judge Orrick answered in the affirmative:

> The tribes have an implicitly incorporated right under the fishing clauses of the Sevens Treaties not to have the fishery habitat degraded by the actions of man which cause environmental damage resulting in such a reduction of available harvestable fish that the moderate living standard, as implemented through the allocation orders of the District Court in Phase I, cannot be met.
>
> The state has a correlative duty under the Supremacy Clause of the Constitution of the United States, [The United States has a similar duty because it acts as trustee of tribal fishing rights. See Part V,Trust Responsibility, supra.] The duty, moreover,is an affirmative one, independent of the duty of the United States and of third parties, to refrain from degrading or authorizing others to degrade the fish habitat to the extent that would deprive the Tribes

> of their moderate living needs, as implemented through the allocation orders of the District Court in Phase I.
>
> The plaintiffs bear the burden of proving that those actions which are challenged proximately cause the fish habitat to be degraded such that the rearing or production potential of the fish will be impaired or the size or quality of the run will be diminished.
>
> The state has the burden of showing that the environmental damage to the fishery resource provied by the plaintiffs will not impair the Tribes' moderate living needs, as implemented through the allocation orders of the District Court in Phase I. If the treaty allocation of harvestable fish is at 50 percent, then there is a presumption that the moderate living needs are not being met.

Phase II at 1-2 (Amended Judgment January 12, 1981), (emphasis added).

The Phase II opinion states that "the most fundamental prerequisite to exercising the right to take fish is the existence of fish to be taken." Phase II, 506 F. Supp. at 203. Prerequesite environmental conditions identified by the court include, "(1) access to and from the sea, and (2) an adequate supply of good quality water...," Id. (emphasis added).

The Phase II right encompasses actions by federal agencies such as the Bonneville Power Administration, Army Corps of Engineers, and Bureau of Reclamation: "neither party to the treaties, nor their successors in interest, may act in a manner that destroys the fishery." Id. at 204 and cases cited therein. The prohibition applies equally to federal agencies, states, and third parties. Id. at 208. The court further held that artificially-propogated fish are included in the Phase I 50-50 allocation. Id. at 202.

The Phase II opinion is consistent with the implied reserved waters doctrine first recognized in Winters v. United States, 207 U.S. 564 (1908) (discussed infra). The implied environmental right to protect the treaty fishery and the inclusion of hatchery fish in the treaty allocation is an essential to effect the purposes of the treaties as the implied reserved water right in Winters. Furthermore, the Phase I and Phase II legal principles are directly applicable to the Columbia River treaty tribes. The fishing clauses in the treaties involved in the Phase I and Phase II litigation are virtually identical to those found in the four Columbia Basin tribes' treaties. See Sohappy v. Smith 529 F 2d. 570, 575 (9th Cir. 1976). All are Stevens treaties.

C. A Substantive Right

The substantive environmental nature of Indian treaty fishing rights was addressed by the courts even prior to the Phase II decision. It is clear that the tribes' treaty fishing right is more than a right to take fish vis a vis others who wish to take fish; it is a right encompassing the protection of the fishery habitat. Furthermore, this right has been applied to several Federal agencies which are integral parties to the operation and management of the Columbia River hydroelectric system.

In Confederated Tribes of the Umatilla Indian Reservation v. Callaway, Civil No. 72-211 (D. Or. August 17, 1973), an Oregon federal district court held that federal water managers cannot manipulate the Federal Columbia River Power System (FCRPS) projects in derogation of tribal fishing rights. The court ordered the Bonneville Power Administration and the Army Corps of Engineers to manage and operate the FCRPS's peak power system in a manner that does not "impair or destroy" the tribe's treaty fishing rights. As a result of this litigation, the Bonneville Power Administration signed a Memorandum of Understanding with the Columbia treaty tribes in which Bonneville Power Administration acknowledged that "operation of the Federal Columbia River Power System (FCRPS) may be subject to restraints on peaking and rates of flow for the protection of the fishery resource, even though such restraints may reduce power generation." "Memorandum of Understanding between the Bonneville Power Administration and the Columbia Basin Indian Tribes" (Nov. 29, 1976), at 2. Though the agreement obligates the Bonneville Power Administration to exert its "best efforts" to improve the fishery, the tribes believe its trustee has not fulfilled its commitment.

In 1977 an Oregon federal district court enjoined the Army Corps of Engineers from constructing a dam and reservoir that would have inundated tribal usual and accustomed fishing sites. In Confederated Tribes of the Umatilla Indian Reservation v. Alexander, 440 F. Supp. 553 (D. Or. 1977), the court found that a proposed Corps of Engineers dam on Catherine Creek would violate tribal fishing rights by inundating the tribes' usual and accustomed fishing stations and by completely eliminating the steelhead run upstream from the dam. Finding no express Congressional intent to abrogate treaty rights, the court refused to infer congressional authorization. The court rejected the Corps' argument that adverse impacts to treaty fishing rights would be mitigated by transporting chinook salmon around the dam.

Recommended to the Council is that a process be established, whereby all proposed hydroelectric development on the Columbia River and its tributaries undergoes review prior to preliminary permitting or funding. One aspect of the review is to determine whether any usual and accustomed Indian fishing stations will be inundated. If inundation would occur, permitting and funding processes must be ceased. Such a review is clearly consistent with the holding in Alexander--that inundation of usual and accustomed Indian fishing stations may occur only with express and specific action of Congress to nullify treaty rights. Id. at 555. Furthermore, such review is required by the fiduciary obligations of federal water managers acting in their capacity as trustee to affirmatively protect tribal fishing and water resources.

The Phase II right to environmental protection for treaty fishing rights required a federal water management agency to provide needed water flows for fish. In Kittitas Reclamation District v. Sunnyside Valley Irrigation District,

No. 21 (E.D. Wash. Nov. 28, 1980), appeal noted (Nov. 26, 1980), the Washington Federal District Court agreed that the Yakima Tribes' implied environmental right to have its treaty fisheries maintained required the Department of Interior's Bureau of Reclamation to release sufficient water at three of its irrigation dams to sustain spring chinook salmon spawning beds. Id. at 3. The court ordered the Watermaster to maintain a water flow of approximately 650 cubic feet per second in a particular section of the Yakima River during the 1980-81 non-irrigation season. Id.

Kittitas is especially applicable to recommendations that minimum flows be provided for juvenile migration of anadromous fish. In concert with other water power managers, the Bureau of Reclamation presently operates several major dams in the Columbia River system. Studies undertaken to ascertain biologically sound flows at the dams on the Columbia River system as well as flows in the interim have been recommended. It is clear that the water power managers are under an obligation to protect treaty fisheries by providing flows wherever necessary. To refuse recommendations for minimum flows would be inconsistent with the Tribes' established treaty rights and violative of Section 4(h)(6)(D) of the Regional Power Act.

In a licensing proceeding before the Nuclear Regulatory Commission's (NRC) Atomic Safety and Licensing Board, the NRC board recognized that an important corollary to Indian fishing rights is the federal government's obligation "that the fish not be destroyed nor their quantities diminished...." In Re Puget Sound and Light Company (Skagit Nuclear Power Project, Units 1 and 2), LBP-78-38. 8 NRC 587, 592 (1978). The Upper Skagit Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Tribal Community petitioned to intervene in hearings on the licensing of two nuclear power plants adjacent to the Skagit River. These tribes retain fishing rights at usual and accustomed fishing grounds and stations by virtue of the Treaty of Point Elliot, 12 Stat. 927. The NRC decision and order granting the tribes' request for intervention stated:

> The protection intended by the treaty is to avoid any lessening of the number of fish that could by available from the natural environment.

8 NRC at 593.

D. Summary

Tribal fishing rights are as valuable to the Columbia treaty tribes as the air they breathe. In the Stevens treaties, these tribes reserved to themselves a right they have practiced since time immemorial: the right to fish at all usual and accustomed fishing sites regardless of where these sites are located. The Supreme Court has determined that the tribes are entitled to 50 percent of fish runs passing by Indian fishing sites. This right is to be respected by the states and the United States Government because under the United States Constitution it is the supreme law of the land. The right to fish is worthless if all or most of the fish are killed before they return to tribal fishing grounds Consequently, there is an environmental component to the tribes' fishing right: individual citizens, states, and the United States must not degrade the fishery habitat so as to deprive the tribes of their 50 percent share. The right to environmental protection includes access to and from the sea and sufficient water quality.

As mentioned, the anadromous fishery in the Columbia River system, including the Indian treaty fishery, is badly depleted. The greatest cause is the existence of some 14 immense dams on the mainstem of the Columbia River. The drafters of the Regional Power Act were well aware of the impacts these dams continue to have on the anadromous fishery. To remedy this situation, the drafters envisioned that these hydroelectric facilities would be operated in a manner providing equitable treatment for fish purposes. Indian treaty rights expand this directive by affirmatively requiring that dams on the Columbia River and its tributaries be operated in a manner which does not impair or destroy the treaty fishery. In addition the Phase II decision imposes a negative duty--that the federal government must refrain from degrading or authorizing others to degrade the fish habitat so as to deprive the Tribes of their treaty fishery.

Since 1973, the Bonneville Power Administration and the Army Corps of Engineers have under a federal court order to operate the Federal Columbia River Power System in a manner that does not "impair or destroy" the tribes' fishing right. These agencies to date have failed to honor this court order.

Reserved Water Rights

The Columbia River treaty tribes hold title to water of the Columbia and its tributaries under two similar yet distinct doctrines of Indian law. The first is the so-called "Winters Doctrine" of reserved water rights; the second is the aboriginal rights doctrine, recognized by the U.S. Supreme Court in United States vs. Winans, 198 U.S. 371 (1905). The import of these rights may be simply stated. The tribes have the right to sufficient quantity and quality of water to protect fish and wildlife habitat as is necessary to satisfy the tribes present and future needs.

A. The Winters Doctrine

Although there is no express language in the Stevens treaties reserving water, the Columbia treaty tribes hold equitable title to water located both within and outside their reservations. The Supreme Court in Winters v. United States, 207 U.S. 564 (1908), established the doctrine of implied reservation of water (Winters Doctrine). The Winters Doctrine has been extended to other, non-Indian federal reservations and the Supreme Court recently affirmed and summarized the essential attributes of the Winter Doctrine in a case involving federal--not Indian--water rights:

> This court has long held that when the federal government withdraws its land from the public domain and reserves it for a federal purpose the government by implication reserves appurtenant water then unappropriated to the extent needed to accomplish the purpose of the reservation. In doing so the United States acquires a reserved right in unappropriated water which vests on the date of permits federal regulation of navigable streams and the Property Clause, Art. IV § 3 which permits federal regulation of federal lands. The doctrine applies to Indian reservations and other federal enclaves encompassing water rights in navigable and non-navigable streams... [citing cases]

Cappaert v. United States, 426 U.S. 128, 138 (1976).

In Winters, the court ruled that when the Fort Belknap Indian Reservation was established by treaty and by subsequent agreement, there was impliedly reserved from appropriation an amount of water sufficient to fulfill the purposes of the reservation and relevant extrinsic evidence and concluded that the parties to the agreement must have intended to reserve water because the land was "practically valueless" with irrigation. 207 U.S. at 576. In his Winters opinion Justice McKenna focused on the tribe's intent:

> The Indians had command of the lands and the waters - command of all their beneficial use... Did they give up all this? Did they reduce the area of their occupation and give up the waters which made it valuable or adequate?

Id.

Consistent with his opinion in Winans two years earlier, Justice McKenna answered his rhetorical questions in the negative. Therefore, Winters stands for the principle that the Indians reserved to themselves - did not grant - the right to the use of water when their reservation was created by treaty and subsequent agreement. Veeder, Indian Prior and Paramount Rights Versus State Rights, 51 N.D.L. Rev. 107, 129 (1974-1975).

1. Attributes of Indian Reserved Water Rights

Indian reserved water rights are usufructuary rights--that is, Indian tribes and members are entitled only to the use but not the corpus of the waters reserved. United States v. Ahtanum Irrigation District, 236 F.2d 321, 328-29 (9th Cir. 1956), cert. denied, 252 U.S. 988 (1957); Tweedy vs. Texas Company, 286 F. Supp. 383, 385-86 (D. Mont. 1968). The Indian reserved water right is a legally cognizable private property right. United States vs. truckee-Carson Irrigation District, 649 F.2d 1286, 1305 (9th Cir. 1981) (Truckee-Carson); Colville Confederated Tribes v. Walton, 647 F. 2d. 42, 49-50 (9th Cir. 1981). Indian reserved water rights are similar to real property. United States v. Ahtanum Irrigation District. 236 F.2d 321, 339 (9th Cir. 1956), cert. denied, 252 U.S. 988 (1957). See Veeder, Confiscation of Indian Water Rights in the Upper Missouri River Basin, 21 S.D.L. Rev. 282, 291 (1976). Compensation must be paid for the taking of congressionally recognized Indian property interests (i.e. reserved water rights) pursuant to the Fifth Amendment to the Constitution of the United States. United States v. Sioux Nation, ___ U.S. ___, 100 S. Ct. 2716, 2740 N.29 (1980). Moreover constitutional procedural due process requirements must also be satisfied in Indian water right taking cases regardless of whether the Indian reservation is created by executive order or by congressional action. Truckee-Carson, 659 F.2d at 1305. Ground water is also an essential component to The Indian's Waters Doctrine rights. See Cappaert v. United States, 426 U.S. 128, 142 (1976); Tweedy v. Texas Company, 286 F. Supp. at 385; United States v. Anderson, Civ. No. 3643 , (E.D. Wash. 1979).

Despite certain similarities, Indian reserved water rights must not be confused with federal reserved water rights. The two water reservation doctrines differ fundamentally. First, and most significantly, Indian water rights are private property interests while federal water rights are public property interests. Ranquist, The Winters Doctrine and How it Grew: Federal Reservation of Rights to the Use of Water, 1975 B.Y.U.L. Rev. 639, 655. Second, the purposes for creating Indian reservations are broader than for creating federal reservations. For example, a purpose of nearly all Indian reservations is to create a permanent tribal homeland. The courts have expressly recognized the Indian's needs to maintain themselves under changed circumstances and have held that this implies flexibility of purposes. Walton, 647 F.2d at 49; cf. United States v. New Mexico, 438 U.S. 696 (1978). Third, special canons of construction are used in interpreting the purposes for which reservations were created (these canons are delineated in Part V. Trust Responsibility, infra), but no similar canons of construction apply to federal reserved water rights. Fourth, certain Indian tribes, such as the Columbia River treaty tribes, have lived on lands that comprise their present reservations since time immemorial. Water rights associated with aboriginal customs antedate federal reserved water rights making them superior to federal reserved water rights in this respect. (See aboriginal water rights discussion, infra). Fifth, because Indian reserved water rights are held in trust by the United States for the tribes, Indian water rights reqwuire a much stricter standard for protection. United States v. Truckee-Carson Irrigation District, 649 F.2d 1286 (9th Cir. 1981) 5170 comments 8, 9, + 5 (1959); Pyramid Lake

Paiute Tribe v. Morton, 354 F. Supp. 252 (D.D.C. 1972); See Pelcyger, The Winters Doctrine and the Greening of the Reservations 4 J. Contemp. L. 19 (1977). Sixth, Indian reserved water rights can exist outside Indian reservations (e.g. Columbia Basin tribes water rights for fishery water needs in the Columbia and Snake River systems).

Of course, both Indian and federal water rights are in many ways antipodal to the prior appropriation doctrine which controls the acquisition of water rights in much of the West. The most significant difference is that prior appropriation waters must be put to beneficial use or the right is lost, whereas reserved water rights are not lost by non-use. See generally Ranquist, The Winters Doctrine and How it Grew: Federal Reservation of Rights to the Use of Water, 1975 B.Y.U.L. Rev. 639; Maxfield, et al, Natural Resources Law on American Indian Lands, Chp. 7 (1977).

2. The Quantity of Water Reserved

Columbia River treaty tribes reserves sufficient water to satisfy all present and future needs. In Conrad Investment Co. v. United States, 161 F. 829 (9th Cir. 1908), the court considered the amount of water the Blackfeet Tribe was entitled to in Birch Creek. The court stated that it is "the policy of the government to reserve...water...reasonably necessary... not only for present uses, but for future requirements...." Id. at 832 (emphasis added). The court affirmed the district court's retention of jurisdiction to modify the decree "should the conditions on the reservation at any time require such modification. Id. at 835. The Yakima Tribe's reserved water rights at Ahtanum Creek were in dispute in United States v. Ahtanum Irrigation District, 236 F. 2d 321 (9th Cir. 1956), cert. denied 352 U.S. 988 (1957).

Finding the Yakima's water right to be paramount under the Winters-Winans rationale, the court said the "right of the Indians to the waters of Ahtanum Creek was not limited to use of the Indians at any given date but this right extended to the ultimate needs of the Indians as those needs and requirements should grow..." Id. at 327 (emphasis added). See Skeem v. United States, 273 F. 93, 95 (9th Cir. 1971) (Held that Ft. Hall tribes' reserved water rights would expand to accommodate irrigation of "the whole of their lands so reserved to their use").

The Supreme Court first considered the quantification of Indian reserved water rights in Arizona v. California, 373 U.S. 546 (1963). In its opinion, the court rejected the states' suggested test of "reasonable foreseeable needs." Id. at 600-601. Instead, the court followed the Conrad-Skeem-Ahtanum line of cases and held that five southwest tribes were entitled to sufficient water in the Colorado River and its tributaries "to satisfy the future as well as the present needs of the Indian Reservations...enough...to irrigate all the practicably irrigable acreage on the reservations." Id. at 600. In its 1979 supplemental decree to Arizona vs. California, the Supreme Court made clear that the "irrigable acreage" standard established a ceiling on the quantity of the southwest tribes' agriculture water right but did not limit the uses to which the water could be applied. Arizona v. California, ___ U.S. ___, 99 S. Ct. 995, 996 (1979), See also Walton, 647 F. 2d 42, 48-49.

The Arizona v. California "irrigable acreage" standard is applicable to the quantification of Columbia treaty tribes' agricultural Winters Doctrine rights. The standard, however, is inappropriate as a guage of the Columbia treaty

tribes fish and wildlife water right since the latter right is in addition to the agriculturel right. Walton, 647 F. 2d at 47-48; Andersen, Civ. No. 3643 at 6/ ; United States v. Adair, 478 F. Supp. 337, 346 (D. Or. 1974) appeal filed ( ). However, the basic principle of Arizona v. California is appropriate: the tribes have the right to sufficient quantity and quality of water to protect the fish and wildlife habitat as is necessary to satisfy the tribes' present and future needs in order to maintain the purposes for which the reservation is created.

3. Purposes for Which Water is Reserved

The quantity of water reserved is dependent upon the purposes for which the Indian reservation was created. One of the "paramount purposes" of the Stevens treaties is "the right to continue fishing as an economic and cultural way of life." Phase II, 506 F. Supp. 187, 205. Without sufficient water flows to preserve fisheries, the right to take fish is worthless. Id.; United States v. Adair, supra 478 F. Supp. 337, 346. Fishery related water flows are essential to the Columbia River treaty tribes in order to effectuate the express purposes of the treaties to the same extent that irrigation-related water reservations were essential in Winters and Arizona v. California to implement the purposes in creating the Montana and southwest tribes' reservations. (Arizona v. California did not involve aboriginal water rights). Since the Stevesn treaties expressly guarantee Columbia River tribes the right to fish anywhere on the reservation and at usual and accustomed sites off the reservation, no meaningful distinction can be drawn under the Winters Doctrine between reserved water rights on and off the reservation. See Pelcyger, The Winters Doctrine and the Greening of the

Reservations, 4 J. Contemp. Law 19, 26 (1977). Thus, Columbia treaty tribes reserved sufficient water flows to protect and sustain their present and future fishing needs on their reservations and at usual and accustomed sites off the reservation; water flows were (and are) absolutely essential to the fullfillment of the Stevens treaties' fishing clauses. Phase II, supra, 506 F. Supp. 287, 305-305.

B. Aboriginal Water Rights

Aboriginal water rights supplement and complement the Winters Doctrine reserved water rights. While Winters Doctrine rights expressly or impliedly reserve sufficient resources necessary to carry out the purposes of the reservation, aboriginal rights consist of rights held by the Indian tribe from time immemorial which were not granted away, by treaty or otherwise. Another distinction of importance to the western water law of prior appropriation is the fact that the priority date of Winters Doctrine rights is the date of the creation of the reservation, while aboriginal rights date back to time immemorial. As a practical matter, this distinction is not crucial; River treaty tribes' reserved rights date to the 1850's, the date of the signing of the Stevens treaties, well before the settlement and appropriate of most non-Indian settlers.

The concept of aboriginal rights was first addressed by the United States Supreme Court in United States v. Winans, 198 U.S. 371 (1905), a fishing rights case interpreting in 1859 "Stevens" treaty with the the Yakima Indians. At issue was the operation of a "fish wheel" by landowners who held legal title to a "usual and accustomed" fishing station by virtue of a federal patent.

Because of its size, the fish wheel excluded the Indians from occupying and fishing from their station. The court interpreted the "in common with" language to guarantee access to the tribes by imposing a servitude on non-Indian land. The court explained that,

> the right to resort to the fishing places in controversy was a part of larger rights possessed by the Indians, upon the exercise of which there was not a shadow of an impediment and which were not much less necessary to the existence of the Indians than the atmosphere they breathed...In other words, the treaty was not a grant of rights to the Indians but a grant of rights from them--a reservation of those not granted. (Emphasis supplied)

198 U.S. at 381.

Thus in Winans, the Yakimas (and by implication other Columbia River tribes) reserved an easement upon ceded land to gain access to their usual and accustomed fishing stations, thus supplementing and effectuating their reserved right to fish. Similarly, the tribes have an aboriginal right to a sufficient quantity fo water of an adequate quality to support the fish. Phase II supra, 506 F. Supp. 187, 203 (1980). The aboriginal water right

Of course, aboriginal rights are not limited to fishing and water rights. Reserved and aboriginal rights have long been recognized by the Supreme Court and are tenets of Indian natural resources law.

The basis of this doctrine lies in the historical relationship between the Indians and the United States. As owners of the soil and waters from time immemorial, the Indians enjoyed the right to make use of all of its resources as they saw fit unless and until restrictions are imposed by the federal government. United States v. Shoshone Tribe of Indians, 304 U.S. 111 (1938); Winters v. United States, 207 U.S. 564 (1908); United States v. Winans, 198 U.S. 371, 381 (1905); United States v. Cook, 86 U.S. 591, 593 (1874); Johnson v McIntosh, 21 U.S. 543, 574 (1823); 34 Op. Att'y Gen. 171 (1924).

The cession of tribal lands to the United States and the creation of a reservation necessarily imposes restrictions on the tribes to the extent of the extinguished rights which they expressly granted to the government via the treaty, statute or executive order which creates the reservation. The creation of a reservation has an additional effect of confirming the Indian's aboriginal rights which were retained. Antoine v. Washington, 420 U.S. 194, 196-197, (1975); Oneida Indian Nation v. County of Oneida, 414 U.S. 661, 667 (1974); United States v. Shoshone Tribe of Indians, 304 U.S. 111 (1938); United States v. Santa Fe Pac. R. Co., 314 U.S. 339 (1941); United States v. Winans, 198 U.S. 371, 381 (1905).

The doctrine of aboriginal title originally was applied to possessory interest in real property. Further, the theory of aboriginal Indian title, and

its relationship to European concepts of title, is based on international law, as elaborated by the Supreme Court in several early opinions. E.g., Mitchel v. United States, 34 U.S. 711, 745-53 (1835); Johnson v. McINtosh, 21 U.S. 543, 572-84 (1823); see generally Cohen, Federal Indian Law 291-94 (1942) In the Americas, discovery gave the European powers control over the territory claimed against each other but not aginst the Indian tribes. The aboriginal Indian title--sometimes called a right of possession or occupation--was respected until extinguished by abandonment, purchase or by just wars. Mitchel, 34 U.S. at 745-46. Until so extinguished, it was good against all the world except the new sovereign. Id.; Oneida Indian Community v. County of Oneida, 414 U.S. 661, 668 (1974); United States v. Santa Fe Pac. R. Co, 314 U.S. 3939, 345 (1941) [Santa Fe]. While the United States owns the underlying fee it will only "take effect in point of possession when their [the Indians] right of possession ceases." Cherokee Nation v. Georgia, 30 U.S. 1, 17 (1831).

These rules were absorbed into our law upon independence. Johnson, 21 U.S. at 584-89. Under the Constitution, the sole right to extinguish aboriginal Indian title was vested in the national government. Oneida, 414 U.S. at 667. The doctrine of Indian title was accommodated to the land tenure forms of the common law by characterizing the underlying ownership of the land as ownership of the fee, subject to the aboriginal Indian title.

> "Their [The Indians'] right of occupancy has never been questioned, but the fee in the soil has been considered in the government."
> Worcester v. Georgia, 31 U.S. 515, 580 (1832).

The tribe's aboriginal title exists without reference to any recognition or grant from the United States:

> [A] tribal right of occupancy, to be protected, need not be "based upon a treaty, statute, or other formal government action." Oneida, 414 U.S. at 669, quoting from Santa Fe, 314 U.S. at 347; See also Cramer v. United States, 261 U.S. 219, 229 (1923).

When a tribe cedes some of its aboriginal lands under a treaty, and retains the balance, and the United States recognizes and guarantees the Indians' title to the balance (as was common and as happened with the Columbia treaty tribes in the 1850's), the only thing "conveyed" by the United States to the tribe is protection of the tribe's preexisting, aboriginal Indian title against an uncompensated taking by the United States itself. United States v. Sioux Nation, ____ U.S. ____, 100 S. Ct. 2716, 2740 n.29 (1980). In all other title respects, the treaty serves only to confirm to the tribe what it already had. United States v. Winans, 198 U.S. 371, 381 (1905) ("the treaty was not a grant of rights to the Indians, but a grant of right from them--a reservation of those not granted").

The Doctrine of Aboriginal title applies to the fishing rights of the Columbia River treaty tribes and preserves those rights and resources held from time immemorial and not granted away or otherwise extinguished by treaty, statute or executive order. The Columbia River treaty tribes possessed aboriginal title to usual and accustomed fishing sites and were fishing based

cultures before the United States was formed, See Sohappy v.Smith , 302 F. Supp. at 906. The tribes have never abandoned their rights. When the Columbia treaty tribes signed the Stevens treaties, they implicitly reserved sufficient quantities of water to protect the resources and rights not granted to the United States, including the fishing rights. These treaties were then recognized and made effective as a reserved right by the ratification of the United States Senate. The Columbia treaty tribes aboriginal water rights expand and supplement the Winters Doctrine as traditionally framed. First, aboriginal water rights offer a means of securing water for purposes other than, and in addition to, the express purposes of the reservation. See generally Merrill, Aboriginal Water Rights, 20 Nat. Res. J. 45 (1980). Second, like the Phase II component to the tribes' fishing right, the aboriginal water right can be (and has been) invoked to protect water quality as well as fish and wildlife habitat. See Pelcyger, The Greening of the Reservations, at 19 and 34 (Winters Doctrine can also be seen as a substantive National Environmental Policy Act). Third, the priority date of the reserved water right is time immemorial rather than the date of the creation of the reservation. Thus, the aboriginal water right predates and would be superior to federal reserved water rights. Adair, 478 F. Supp. 337, 350 (Klamath Tribe's reserved water right on Williamson River entitled to "time immemorial priority date ") (discussed infra).

C. Recent Court Decisions

1. Colville Confederated Tribes v. Walton

In Colville Confederated Tribes v. Walton, 647 F. 2d 42 (9th Cir. 1981). the Ninth Circuit found an implied Winters Doctrine right to sufficient water to maintain fisheries in the No Name Creek--Omak Lake water system, located within the Colville Reservation. The purposes of creating Indian reservations, the court stated, should be construed broadly, taking into consideration the need for tribes "to maintain themselves under changed circumstances." Id. at 47. Because the Colville Tribes' historic fishing grounds on the Columbia River had been destroyed by dams, the tribe planted non-indigenous trout in Omak Lake as replacement fisheries. The court upheld tribal reserved water rights for these replacement fisheries:

> The right to water to establish and maintain the Omak Lake fishery includes the right to sufficient water to permit natural spawning of the trout. When the Tribe has a vested property right in reserved water, it may use it in any lawful manner. As a result, subsequent acts making the historically intended use of the water unnecessary do not divest the Tribe of the right to the water.

Id. at 48 (emphasis added).

2. United States v. Anderson

In United States v. Anderson, Civ. No. 3643 (E.D. Wash., July 23, 1979), the spokane Tribe intervened in an adjudication of water rights in Chamokane Creek, which forms the eastern boundary of the Spokane

Reservation. The tribe asserted reserved water rights for the irrigation of crops, for a fishery, and for recreational and esthetic purposes. Adjudication of the claim for water to irrigate crops was easily disposed of under Arizona v. California, Winters, and Winans, supra. The court also found that maintenance of the creek for fishing had been a purpose for creation of the reservation, and therefore, the tribe had a reserved right to a quantity of water sufficient to preserve the fish stocks of Chamokane Creek. The quantity of water necessary to maintain the fishery was found to be dependent on water temperature, which in turn was related to minimum flows. To maintain the fishery, the court held that the tribe had a reserved water right as measured by the amount of water necessary to maintain the creek's water temperatures at 68°F or less, and that the flow could at no time decline below 20 cubic feet of water per second. United States v. Anderson, No. 3643 slip op. at 10 (E.D. Wash., July 23, 1979).

The tribe historically had used the creek and its fish stocks as a food source. Therefore, the tribe asserted that the priority date which should attach to the water right necessary to maintain the fishery was "time immemorial," rather than the date the reservation was established. The court, however, declined to rule on that issue, since on the facts the tribe's reserved rights were superior to the defendant's claims regardless of how the priority date was set. Id. at 10. Nontheless, the case marks a clear recognition by a federal court that "aboriginal water rights" is a truly distinct subcategory within the generic category of Indian reserved water rights. The case stands as a landmark for its recognition that aboriginal water rights serve to expand and supplement the more general notion of Winters water rights.

3. United States v. Adair

In United States v. Adair, 478 F. Supp. 337 (D. Or. 1979), the Oregon Federal District Court defined the Klamath Tribe's right to water for fish and wildlife in the Williamson River. The Klamath Reservation was terminated in 1961 but the tribe's treaty hunting and fishing rights survived the termination. Kimball v. Callahan, 590 F. 2d 768 (9th Cir. 1979). Tribal members have hunted, fished and gathered food on the Klamath reservation lands since time immemorial. Id. at 345. Quoting Winans, the court held that the Klamaths had reserved to themselves sufficient water to protect their hunting and fishing rights. If the preservation of these rights requires that the Williamson River marsh be maintained as wetlands and that the forest be maintained on a sustained yield basis, the court required that sufficient water is reserved for those results. Id. at 347.

The priority date of the tribe's hunting, fishing, trapping and gathering rights was held to be time immemorial. Id. at 350. The priority date for the Indian's water right for irrigation and domestic purposes is 1864, the date the reservation was established. The court clearly recognized the distinctions and relationships between the tribe's reserved water right for aboriginal purposes. In the case of the former sufficient water was reserved to further one of the purposes of the reservation, i.e. agriculture, which had a priority date as of the creation of the reservation. In the case of the latter hunting and fishing rights, sufficient was reserved by the Klamath Indians to preserve the habitat of the objects of their traditional hunting and fishing lifestyle, with a priority date of "time immemorial."

4. United States v. Washington - Phase II

Judge Orrick, in United States v. Washington Phase II, 506 F. Supp. 187 (W.D. Wash. 1980), recently recognized that the Indian's right to take fish, as explicitly bargained for in the Stevens treaties, also included the right to protect the habitat from manmade despoliation. Id. at 203. The court recognized, consistent with Colville Confederated Tribes v. Walton, U.S. v. Anderson and United States v. Adair, supra, that the tribes had reserved a sufficient quantity of water to fulfill the purpose of the fishing clause. More important , the court recognized that the fishing right included the right to "have the fishery habitat protected," Id. at 203, thus recognizing a reserved right to water quality as well as quantity.

F. Summary

The Columbia River treaty tribes impliedly reserved to themselves sufficient water to satisfy the needs of a permanent tribal homeland: their respective reservations. Included idn their reserved Winters right is sufficient water to meet their present needs and all future needs. As aboriginal tribes who have fished in the Columbia River and its tributaries for millenia, the priority date of their fisheries water right is time immemorial--antedating all other water rights in the Columbia Basin. Federal courts have uniformly recognized reserved water rights to protect reserved fishing rights because fishing rights without adequate water would be worthless. Neither party bargained for a worthless right in the Stevens treaties.

Reserved water rights, like fishing rights, are some of the most valuable and essential private property interests owned by these tribes. Without either property interest, tribal economy, culture, and religion would be destroyed. Constitutional protections, including both substantive and procedural due process, adhere to these fishing and water rights. No meaningful distinction can be drawn between water rights reserved on and off the reservations. Tribal reservation of fishery rights--on and off the reservation--was expressly recognized by the United States in the Stevens treaties; with it came the aboriginal water right. Synergistically, reserved fishing and water rights require water quality protection, including necessary water temperature.

The Regional Power Act req uires inter alia, that the Council include in its program measures which will provide

> flows of sufficient quality and quantity between such (hydroelectric) facilities to improve production, migration, and survival of such fish as is necessary to meet sound biological objectives.

Section 4(h)(6)(E)(ii), 16 U.S.C. 839 (b)(h). The Columbia River treaty tribes have held rights to such flows since time immemorial. It is incumbent upon the Council to develop recommendations consistent with the Indian Winters doctrine and aboriginal reserved water rights to maintain flows to protect their anadromous fishery.

In order to maintain themselves and their culture under changing economic, social, and political conditions, and to maintain a permanent tribal homeland, Columbia River treaty tribes are entitled to a biologically healty fishery. The Columbia River tribes have historically been denied that right; yet they remain confident that the passage of the Regional Power Act will provide one means to satisfying their rights.

Tribal Co-Management Authority

The Columbia River tribes aboriginal fishing and water rights merge to produce the right to co-manage these important tribal property interests. Historically, federal water managers on the Columbia River and its tributaries have failed to adequately protect these tribal property interests. The Columbia treaty tribes have never surrendered their right--as quasi-sovereign nations--to share management responsibilities with their trustees over these important property rights.

Indian tribes retain extensive governmental powers within reservation boundaries. Indian tribes are unique aggregations possessing attributes of sovereignty over both their members and their territory. United States v. Wheeler, 435 U.S. 313. 323 (1978) (criminal jurisdiction); United States v. Mazurie, U.S. 544, 557 (1975) (civil). A tribe retains the inherent power to exercise civil authority over the conduct of non-Indians on fee lands within its reservation when that conduct threatens or has some direct effect on the health and welfare of the tribe. Montana v. United States, ___ U.S. ___, 101 S. Ct. 1245, 1257 (1981). Within reservation boundaries, Indian tribes have at a minimum, co-regulatory authority shared with the federal government over all waters within the exterior boundaries of the reservation; state water laws have no force or effect over such waters. Colville Confederated Tribes v. Walton, 647 F. 2d 42, 52 (1981).

Tribal government powers extend beyond reservation boundaries. Columbia River treaty tribes have held Indian title to off-reservation water and fishing rights since time immemorial. Inherent tribal sovereignty logically includes the power to regulate the most fundamental and basic property interests of the tribes: water and fishing rights. The Supreme Court honors retained tribal governmental sovereignty:

> The sovereignty that the Indian tribes retain is of a unique and limited charater. It exists only at the sufferance of Congress and is subject to complete defeasance. But until Congress acts, the tribes retain their existing sovereign powers. In sum, Indian tribes still possess those aspects

> of sovereignty not withdrawn by treaty or statute, or by implication as a necessary result of their dependent status.

United States v. Wheeler, 435 U.S. 313, 322 (1978) (citations omitted) (emphasis added). Congress has never repeated the Columbia River tribes' regulatory authority over its on-reservation or its off-reservation hunting and fishing rights. Therefore, tribal regulatory authority over fishing and concomitant water flows both within the reservations and at all usual and accustomed fishing sites outside the reservations are retained tribal governmental powers.

Tribal regulatory control over Indian fishing at all off-reservation usual and accustomed fishing sites was confirmed in Settler v. Lameer, 507 F.2d 231, 237 (9th Cir. 1974). There, the Ninth Circuit held that:

> It would be unreasonable to conclude that in reserving these vital [fishing] rights, the Indians intended to divest themselves of all control over the exercise of those rights ....The Indians must surely have understood that tribal control would continue after the treaty.

Id. at 236 (emphasis added). The court continued:

> In addition, the Treaty of 1855 does not expressly

> state that the Yakima Nation relinquished its jurisdiction over matters pertaining to fishing rights. As the treaty constitues a grant of rights from the Indians to the government, Winans, supra 198 U.S. at 381, 25 S. Ct. 662, 49 L.Ed. 1089, any rights not granted must be considered retained by the tribe. Here the Indians qualified their fishing right only to the extent of permitting citizens of the territory to fish "in common" with them at "usual and accustomed fishing places" off the reservation. Given this fact and the vital role of fishing in the Yakima culture, we conclude that the Yakima Nation did reserve the authority to regulate tribal fishing at "all usual and accustomed places," whether on or off the reservation.

Id. at 237 (emphasis in original).

Columbia River treaty tribes do not assert carte blance co-management authority over the Columbia River and its tributaries. These tribes do assert however, sovereign power to co-equal management of the Columbia River power system to the extent necessary to protect its property interests. As stated in the Ninth Circuit's recent Walton opinion,

> [P]ermitting the Indians to determine how to use reserved water is consistent with the general

> purpose for the creation of an Indian reservation --providing a homeland for the survival and growth of the Indians and their way of life.

Walton, 647 F. 2d at 49.

Increased tribal involvement over their reserved off-reservation fishing and water rights is recognized in two recent decisions affecting management and operation of Pacific Northwest hydroelectric projects. In Confederated Tribes of the Umatilla Indian Reservation v. Callaway, No. 72-211 (August 17, 1973), Federal District Judge Belloni ordered the Army Corps of Engineers and the Bonneville Power Administration to operate the Federal Columbia River Power System in a manner that protects the Umatilla Tribes' fishing rights. The Memorandum of Understanding (MOU) between the Columbia treaty tribes and the BPA, which was negotiated as a result of the Callaway opinion, is premised on a coordinated tribal/federal regional approach to water management. (e.g. The parties "are equally committed to the concept of solving a regional problem on a coordinated regional basis.") MOU at 1. "The purpose of the Memorandum of Understanding is to forge a partnership among the Tribes, BPA, and PNRC [Governors of Idaho, Washington and Oregon et al.]...for undertaking coordinated programs aimed at helping to restore the Columbia River anadromous fishery." MOA, at 3. See Memorandum of Understanding Between the BPA and Certain Columbia Basin Tribes (Nov. 29, 1976).

The Federal Energy Regulatory Commission (FERC) conditionally approved an interim offer of settlement negotiated between certain Pacific Northwest

Tribes and the City of Seattle. After two years of negotiation, the Sauk-Suiattle, Upper Skagit, and Swinomish Tribes signed an agreement providing inter alia for fishery-related water flows, fishery studies, and quarterly reports to the tribes on the Seattle utility's planned manipulation of flows at three dams and impoundments on the Skagit River. See Order Conditionally Approving Interim Offer of Settlement, 14 FERC 61,144, Docket No. EL78-36, Project No. 553 (May 12, 1981); See also Order Delcaring Interim Settlement Effective and Partially Releasing a Condition, 16 FERC 61,044 (July 24, 1981).

Further, inter-tribal co-management of water flows in the Columbia River and its tributaries to protect Indian fishing and water rights is completely consistent with contemporary federal Indian policy. See Indian Self-Determination and Educational Assistance Act, 25 U.S.C. § 450 et seq. (Supp. 1980); Indian Reorganization Act of 1934, 25 U.S.C. § 476 et seq. (1963) ("This bill...seeks further to give the Indians the control of their own affairs and of their own property; to put it in the hands either of an Indian Council or in the hands of a corporation to be organized by the Indians ") 78 Cong. Rec. 11125 (1934).

Congress recently affirmed this policy in enacting the Pacific Northwest Electric Power Planning and Conservation Act, Pub. L. 96-501, 94 Stat. 2703, 16 U.S.C. §§ 839 et seq. That Act establishes a system to manage both conservation, renewable and other power resources consistent with fisheries resources, so as to "protect, mitigate, and enhance fish and wildlife resources" 16 U.S.C. § 839(3)A. Indian tribes and other federal, state, and local governments are expressly included in the management program.

Section 4(h), 16 U.S.C. 839(b)(h) provides the detailed scheme whereby the Indian tribes and other fisheries agencies are to make recommendations as to a management program which will protect, mitigate, and enhance fish and wildlife resources. 16 U.S.C. § 839 (b)(h)(5)+(7). These recommendations are to be adopted by the Power Planning Council unless the Council explains in writing why the recommendations are inconsistent with specific criteria. 16 U.S.C. § 839 (b)(h)(7). The Act explicitly recognizes the legal rights of appropriate Indian tribes in the region and in no way affects their treaty or other legal rights. 16 U.S.C. § 839 (g)(e). Thus, the Regional Power Act (PNEPPCA) clearly recognizes the co-management authority of the tribes to protect their property rights to the water and fisheries resources which they have possessed since "time - immemorial."

Trust Relationship

A. The source of the Trust Responsibility

It is axiomatic that the United States government stands in a fudiciary relationship to Indian tribes.[1/] The source and nature of this trust relationship is unique in American jurisprudence. The first judicial recognition of the fiduciary relationship can be traced back to Justice John Marshall's seminal opinions in Cherokee Nation v. Georgia, 30 U.S. (5 Pet.) 1 (1831), and Worcester v. Georgia, 31 U.S. (6 Pet.) 515 (1832). These two cases form the basic analytical framework upon which Indian law rests today.

In Cherokee Nation, the Supreme Court's first case to interpret an Indian treaty, the state of Georgia attempted to impose its laws on the

Cherokee Nation, which was located within the state. The Cherokees filed suit under Article III of the Constitution which gives the Supreme Court original jurisdiction in cases and controversies involving states and foreign nations. The central question was whether the "Cherokees constitute a foreign nation in the sense of the constitution" Cherokee Nation, 30 U.S. at 16. Justice Marshall concluded that Indian tribes were not a "foreign nation" under Article III, but instead, were "domestic dependent nations,": Id. at 17.

> [T]he relationship of the Indians to the United States is marked by peculiar and cardinal distinctions which exist no where else...Their relation to the United States resembles that of a ward to his guardian.

Id. at 16-17 (emphasis added).

One year after Cherokee Nation the Supreme Court again faced the question of whether the state of Georgia could impose its laws on the Cherokee Nation. The state imprisoned a non-Indian minister named Worcester for living with the Cherokees without state permission. Worcester obtained permission from the Cherokees to live on the reservation, but had not received a permit from the Georgia governor. Holding the state's imposition of its laws within the reservation to be repugnant to the Constitution, treaties, and federal law, Justice Marshall recognized Indian tribes as "distinct, independent, political communities...." Worcester v. Georgia 31 U.S. at 559. The court clarified the nature of its ward-guardian analogy used in Cherokee Nation:

> This relation [under the Treaty of Hopewell] was that

> that of a nation claiming and receiving the protection of one more powerful: not that of individuals abandoning their national character, and submitting as subjects to the laws of a master....
>
> ***
>
> This treaty, thus explicitly recognizing the national character of the Cherokees, and their right of self government; thus guarantying their lands; assuming the duty of protection, and of course pledging the faith of the United States for that protection; has been frequently renewed, and is now in full force. (emphasis added).

Id. at 555-556. Thus, under Cherokee Nation and Worcester the federal government's trust relationship derives from its treaty promises to protect tribal property and political autonomy.

Congressional enactments are another source of the trust relationship. For example, the first statute explicitly recognizing the trust ownership concept of Indian lands was the General Allotment Act of 1887, 25 U.S.C. § 348 (1970) ("the United States does and will hold the land thus allotted...in trust for sole use and benefit of the Indian...."); See, e.g., Joint Tribal Council of Passamaquaddy Tribe v. Morton, 528 F. 2d 370 (1st Cir. 1975) (Held that the Indian Trade and Intercourse Act of 1790 is also a source of the trust relationship).

The trust relationship can also be established by executive orders; See F. Cohen, Handbook of Federal Indian Law 299-302 (U.N.M. ed. 1971); by agreements, Id. at 67 (Agreements are similar to treaties because they are negotiated with tribes by federal officials, but have the sanction of both houses of Congress, rather than just the Senate); and by the course of dealings with the federal government whereby the tribes were left in "a condition of weakness and helplessness." United States v. Kagama, 118 U.S. 375, 384 (1886); See Navajo Tribe of Indians v. United States, 624 F. 2d 981, 986-7 (Ct. Cl. 1980).

B. A Source and Limit to Congressional Control

The trust relationship is also a source of Congressional power, separate and distinct from the Constitution's Article I, Sec. 8, Cl. 3, directive that Congress has the power to regulate commerce with Indian tribes. In Kagama the Supreme Court found authority in the federal-tribal trust relationship to uphold the Major Crimes Act. The opinion proclaimed that "[t]hese Indian tribes are the wards of the Nation. They are communities dependent on the United States....Kagama, 118 U.S. at 383-84 (emphasis in original). It went on to say that: "From their very weakness and helplessness...there arises the duty of protection, and with it the power. Id. at 384 (emphasis added).

In addition to being a source of congressional power, the trust relationship also places limits on Congress. In United States v. Creek Nation, 295 U.S. 103 (1935), the Supreme Court proclaimed that Congress' "power to control and manage is not absolute. While extending to all appropriate measures for protecting and advancing the tribe, it is subject to limitations

inherent in...a guardianship and to pertinent constitutional restrictions." Id. at 110. In United States v. Sioux Nation of Indians, ___ U.S. ___, 100 S. Ct. 2716, 2740 (1980), the Supreme Court quoted this same sentence in Creek Nation and held that when Congress acts as a trustee in managing and controlling tribal lands a presumption of good faith will not be applied. The Ninth Circuit has recently reiterated the holding in Sioux Nation adding:

> [T]he insulation accorded actions by the government-trustee does not apply to instances of government self-dealing because "[s]poilation is not management," [cite omitted] When the government sheds its "trustee" role for one of "taker" the due process clause protects Indian rights....When the government breaches its trust to the Tribes while openly advancing its own interest the Tribe is not necessarily bound.

United States v. Truckee-Carson Irrigation District, 649 F. 2d 1286, 1306-07 (1981) (emphasis added).

C. General Scope and Nature of the Duty

The fiduciary duty is a self-imposed one which arises out of the tribes' status as "dependent domestic nations." Chambers, Discharge of the Federal Trust Responsibility to Enforce Claims of Indian Tribes: Case Studies of Bureaucratic Conflict of Interest, reprinted in Subcomm. on Administrative Practice and Procedures, Senate Comm. on the Judiciary, 91st Cong. 2d Sess., A Study of Administrative Conflicts of Interest in the Protection of Indian

Natural Resources 4-11 (Comm. Reprint 1971), at 1. [hereinafter Chambers, Case Studies of Bureaucratic Conflict of Interest]. The executive branch, and its agencies, are without power to modify or repeal its trustee duty or abrogate solemn treaty rights absent express and explicit direction from Congress. Oneida Indian Nation v. County of Oneida, 414 U.S. 661, 669 (1974); 413 Menominee Tribe v. United States, 391 U.S. 404, 412 (1968) ("the intention to abrogate or modify a treaty is not to be lightly imputed to Congress"); Passenger Fishing Vessel, ___ U.S. at 97 S. Ct. 3055. By contrast, Congress has plenary power to modify or eliminate the trust relationship altogether. Oneida Indian Nation v. County of Oneida 414 U.S. 661, 669-670 (1974).

Whether the responsibility be termed that of a guardian, fiduciary, trustee, protector, or of a superior to a dependent people, the duty imposed on the federal agency is the same. Oneida Tribe of Indians of Wisconsin v. United States, 165 Ct. Cl. 487 (1964), cert. denied 379 U.S. 946 (1964). [insert p. 13a]

The courts often look to the canons of treaty construction in interpreting the federal government's duty to protect the tribes' rights. The canons can be summarized as follows:

1. Indian treaties must be interpreted so as to promote their central purposes; [2/]

2. Treaties are to be interpreted as the Indians themselves would have understood them; [3/]

3. Indian treaties are to be liberally construed in favor of the Indians; [4/]

4. Ambiguous expressions are to be resolved in favor of the Indians; [5/]

5. A treaty is not a grant of rights to the Indians but a reservation of those rights not grant away. [6/]

The obligation of federal agencies, therefore, is to protect and enhance the resources of the tribes so as to promote the central purposes of the rights reserved under the applicable treaty. Thus, under the Stevens treaties, the agencies of the federal government must act to protect and enhance the fishery and water resources which the tribes reserved under those treaties. Without express authorization from Congress, federal agencies can not act in a manner that fails to promote those rights. The Regional Power Act, rather than abrogating those rights, expressly preserves Indian treaty and other rights. 16 U.S.C. 839(g)(e). Therefore, all federal agencies are obligated to protect tribal resources, subject to the appropriate standard of a guardian to his ward.

D. The Fiduciary Standard

"[A]ny federal government action is subject to the United States' fiduciary responsibilities toward the Indian tribes." Nance v. Environmental Protection Agency, 645 F. 2d 701, 711 (9th Cir. 1981) (emphasis in original). When the federal government deals "with these dependent and sometimes exploited people...." it's conduct will be judged by the most exacting fiduciary

standards." Seminole Nation v. United States, 316 U.S. 286, 296-97 (1942) (emphasis added). See e.g. United States v. Mason, 412 U.S. 391, 398 (1973).

In many respects, the Indian trust obligations are similar to common law private trust principles. For example, the Supreme Court has analogized that the federal trustee has a "duty in administering the trust to exercise such care and skill as a man of ordinary prudence would exercise in dealing with his own property." United States v. Mason, 412 U.S. 391, 398 (1973), citing 2 A. Scott, Trusts § 1408 (3d ed. 1967); Coast Indian Community v. United States, 550 F 2d 639, 652-53 (Ct. Cl. 1977). The United States Government has a duty to account to the tribes for its performance of treaty obligations. Navajo Tribe of Indians v. United States, 624 F. 2d 981, 990 (Ct. Cl. 1980). If the federal trustee is negligent in its dealings with the tribes' property, it is liable for any losses. Coast Indian Community v. United States, 550 F. 2d at 653.

The Government, as trustee, is under a duty to administer the trust solely in the interest of the beneficiary. Manchester Band of Pomo Indians, Inc. v. United States, 363 F. Supp. 1238, 1245 (N.D. Cal. 1973) citing Restatement (second) of Trusts, § 170(1) (1959). Moreover, "the trustee is under a duty to the beneficiary to use reasonable care and skill to make the trust property productive." Id.; Restatement (second) of Trusts § 181. If the particular trustee has a greater degree of skill than that of the man of ordinary prudence, however, he will be held liable for any loss resulting from the failure to use skill as he has. Id.; Restatement (second) § 714, comment (a).

These general trust principles have been consistently applied by the courts to the management of tribal financial and natural resources assets. The principles are the same since the tribes have a property right to both financial and natural "resources." For example, the Secretary of the Interior can not dispose of tribal lands under the public land laws, for to do so "...would not be an exercise of guardianship but an act of confiscation." Lane v. Pueblo of Santa Rose, 249 U.S. 110, 113 (1919). Nor can the Secretary of the Interior convey to a railway lands occupied by Indians, even though such occupancy was not protected by any treaty, executive order or statute. Cramer v. United States, 261 U.S. 219 (1923).

These fiduciary obligations also apply to agencies that manage fisheries, water and other tribal resources. A case on point is Pyramid Lake Paiute Tribe v. Morton, 354 F. Supp. 252 (D.D.C. 1972). In this case, the tribe sought and obtained a federal order enjoining diversions of water from a dam and reservoir located upstream from the tribes' reservation. At issue was the Secretary of Interior's "judgment call" in recommending a regulation allowing 378,000 acre-feet of water to be diverted from the Truckee River for irrigation purposes. Of importance to the plaintiff's and of great significance here, the Secretary's proposed impairing the lake's--and the Indians'--fishery.

The court held that the Secretary of Interior violated its trust obligation to protect the Paiute Tribe's fishery. The Secretary's justification, that his "judgment call" was a proper balancing of conflicting interests, was vehemently rejected by the court:

> Furthermore, while the Secretary's good faith is not in question, his approach to the difficult problem confonting his misconceived the legal requirements that should have governed his action. A "judgment call" was simply not legally permissible ...The burden rested on the Secretary to justify any diversion of water from the Tribe with precision. It was not his function to attempt an accommodation.

Id. at 256 (emphasis added). Citing Seminole Nation v. United States, discussed supra, the court declared "the most exacting fiduciary standards" to mean that:

> The secretary was obliged to formulate a closely developed regulation that would preserve water for the Tribe. He was further obliged to assert his statutory and contractual authority to the fullest extent possible to accomplish this result...The Secretary's action is therefore doubly defective and irrational because it fails to demonstrate an adequate recognition of his fiduciary duty to the Tribe. This also is an abuse of discretion and not in accordance with law.

Id. at 256-257.

The court further held that a contract between the Secretary of the Interior and the Secretary of Agriculture which governed reservoir management can not be used as an obstacle to maintaining fish flows: "The Secretary's trust obligations to the Tribe are paramount in this respect." Id. at 258. See generally Chambers, Conflicts of Interest in the Administration of the Federal Trust Responsibility, A report to the Committee on Claims Adjudications of the Administrative Conference of the United States (January 3, 1972); Veeder, Federal Encroachment of Indian Reserved Water Rights and The Impairment of Reservation Development, submitted to the Subcommittee on Economy in Government of the Joint Economic Committee Congress of the United States, 91st Cong. 1st Sess. (Released by Joint Economic Committee January 18, 1970).

E. The Fiduciary Obligations of Bonneville Power Administration

It is clear from the preceding discussion that BPA, like other federal agencies, has fiduciary obligations with respect to the tribal resources it manages; i.e. water and fish. The trust obligations serve to limit BPA's discretion to trade off tribal resources against other interest and impose an affirmative burden on BPA to use its expertise to protect and enhance the production of the tribal fishery rights.

The limits imposed by the trust responsibility on agency discretion are best illustrated by the Pyramid Lake case supra, and by general trust principles. In Pyramid Lake, the court held that despite the agency's good faith, it could not make a "judgment call" which traded off tribal rights against other interests. 354 F. Supp. at 256. An agency must use its full

statutory and contractual authority to act solely to protect and make productive the tribal resources, including water and fish. Only after it has satisfied these trust obligations, may it balance and accommodate other interests. Moreover, the Regional Power Act is perfectly consistent with this analysis. See 16. U.S.C. § 839(b)(h)(6)(d), 16 U.S.C. 839(g)(e). The burden of proof rests with these agencies to justify with precision that their actions will not breach their duty to protect and enhance the tribes' rights. The United States may not breach its trust obligations by advancing its own interests at the expense of its beneficiary; to do so would not be an act of guardianship, but confiscation. Coordinating agreements or contracts with third parties can not be used as an obstacle to satisfying the government's truse responsibilities.

On the other hand, the trust responsibility imposes an affirmative duty upon the agency to use its particular expertise to make the tribal assets productive. This duty is in addition to the negative duty federal and state agencies and third parties must follow in refraining from degrading the fish habitat. See U.S. v. Washington, UPhase II, 506 F. Supp. at 207. Bonneville Power Administration must use its affirmative duties to upgrade the fishery by properly managing the river within its control. The Regional Power Act affirms this duty by directing the agency to protect, mitigate and enhance the decimated salmon resource. BPA's duty to the tribes, of course, requires no less.

FOOTNOTES

1/ Morton v. Ruiz, 415 U.S. 199, 236 (1974); United States v. Mason, 412 U.S. 391 (1973); United States v. Alcea Band of Tillamooks, 329 U.S. 40,47 (1946); Seminole Nation v. United States, 316 U.S. 286, 296-97 (1942); Tulee v. State, 315 U.S. 681 (1942); United States v. Santa Fe Pac. Ry. 314 U.S. 339 (1941); Shoshone Tribe v. United States, 299 U.S. 476 (1937); United States v. Creek Nation, 295 U.S. 103 (1935); United States v. Candelaria, 271 U.S. 432 (1926); United States v. Panye, 264 U.S. 446, 448 (1924); Cramer v. United States, 261 U.S. 219 (1923); United States v. Nice, 241 U.S. 591 (1916); United States v. Pelican, 232 U.S. 442 (1914); United States v. Sandoval, 231 U.S. 28, 45-46 (1913); Choate v. Trapp, 224 U.S. 665, 675 (1912); Heckman v. United States, 224 U.S. 413, 437-38 (1912); Tiger v. Western Investment Co., 221 U.S. 286 (1911); Lone Wolv. Hitchcock, 187 U.S. 553, 664 (1903); Cherokee Nation v. Hitchcock, 187 U.S. 294, 305 (1902); Cherokee Nation v. Southern Kansas Ry., 135 U.S. 641 (1890); Choctaw Nation v. United States, 119 U.S. 1, 28 (1886); United States v. Kagama, 118 U.S. 375 (1886); Fellows v. Blacksmith, 60 U.S. (19 How.) 366 (1856); Cherokee Nation v. Georgia, 30 U.S. (5 Pet.) 1 (1831); see generally Chambers, Judicial Enforcement of the Federal Trust Responsibility to Indians, 27 Stanford L. Rev. 1213 (1975).

2/ United States v. Winans, 198 U.S. 371, 381 (1905) quoted in U.S. v. Washington, 506 F. Supp. 187, 195 (W.D. Wash. 1980) (hereinafter Phase II)

3/ Washington v. Washington State Commercial Passenger Fishing Vessel Assn., 443 U.S. 658, 676 (1979); Choctaw Nation v. Okalahoma, 347 U.S., 620, 630 (1970). Tulee v. Washington, 315 U.S. 681, 684 (1942); Jones v. Meehan, 175 U.S. 1, II (1899) Worcester v. Georgia 31 U.S. (6 Pet.) 515 (1832); Seufert Bros. Co. v. United States, 249 U.S. 194, 198 (1919); United States v. Winans, 198 U.S. 371 (1905); Phase II at 8; See Generally, F. Cohen, Handbook on Federal Indian Law, 37-8, (1940).

4/ Passenger Fishing Vessel Association Supra n.5, 443 U.S. at 676; Antoine v. Washington, 420 U.S. 194, 199 (1975); Choctaw Nation v. United States 318 U.S. 423 (1943); Tulee v. Washington 315 U.S. 681, 684 (1942) Alaska Pacific Fisheries v. United States 248 U.S. 78, 89 (1918); Phase II at 195.

5/ McClanahan v. Arizona State Tax Commission, 411 U.S. 164 (1973); Carpenter v. Shaw 280 U.S. 363 (1930) Fleming v. McCustain 215 U.S. 56, 59-60 (1909) Winters v. United States 207 U.S. 564 (1905); Phase II at 195.
In Winters the court stated that, "By a rule of interpretation of agreements and treaties with the Indians, ambiguities occurring will be resolved from the standpoint of the Indians. And the rule should certainly be applied to determining between two inferences, one of which would support the purpose of the agreement and the other impair or defeat it. On account of their relation to the government, it cannot be supposed that the Indians intended to exclude by formal words every

inference which might militate against and defeat the declared purpose of themselves and the government, even if it could be supposed that they had the foresight to foresee the "double sense" which might some time be urged against them."
207 U.S. at 576-7.

6/ U.S. v. Winans, 198 U.S. 371, 381 (1905). See discussion of reserved rights, supra.

CHAPTER E

History of Fish Runs

CHAPTER E
HISTORY OF FISH RUNS: A PATTERN OF DECLINE

"The Columbia River Basin produces the world's largest runs of chinook salmon and steelhead trout, major runs of coho and sockeye salmon and small numbers of chum and pink salmon. Collectively these runs comprise an unparalleled national resource of international renown.

"Anadromous salmon and steelhead supported a rich native American Indian culture over vast reaches of the Columbia Basin for thousands of years. Beginning in the mid 1800's they were the foundation of a productive non-Indian commercial fishing economy and lifestyle focused in the central and lower reaches of the main-stem Columbia River.

"By the late 1950's ocean sport and commercial fisheries all along the Pacific coast from Alaska to California were harvesting large and increasing numbers of salmon produced in a multitude of Columbia River tributaries.

"By the advent of the late 1970's what were once the largest, most valuable components of the Columbia River salmon and steelhead runs had been progressively reduced to a small fraction of their former abundance.

"The regional social, economic, legal and political trauma which has resulted from decades of progressively increasing conflict among fishermen competing for an ever-dwindling supply of an increasingly valuable resource has frustrated effecting a reversal of this critical situation.

"Most naturally produced salmon and steelhead stocks have declined in productivity. This decline has been particularly precipitous in upriver areas above Bonneville Dam. This decline has resulted in the elimination and near-elimination of fisheries on all upriver summer and spring chinook respectively, once the most valuable, productive salmon runs for in-river fisheries." (Reproduced from unapproved Columbia River Basin Salmon and Steelhead Management Plan, 1981. Columbia River Fisheries Council, 39pp.)

Table 1 lists the estimated run sizes of the most important upriver salmon and steelhead runs, and Figures 1, 2, and 3 illustrate the fluctuations in these runs. Figures 4, 5, and 6 from Junge and Oakley (1966) illustrate the serious decline in production rates by plotting run sizes against the spawning escapements that produced them.

Fall chinook salmon have been throughout this period the most abundant fishery resource in the Columbia River system. Since much of the production has been from hatcheries in the lower Columbia, the lower river stocks have been less severely impacted by the dams. The sharp decline in the late 1940's, for example (Figure 1), is mainly attributable to increased harvest by ocean fisheries.

Summer chinook salmon runs have shown a steady downward trend since 1957. The early run races are destined for the Snake River and tributaries in Idaho and are the most depressed of all runs to the Columbia River. Since its peak in 1957 (Figure 1), the summer runs declined more severely than any other Columbia River chinook stock. By 1980 the run dropped to 35,000 fish from a high of 210,000 fish in 1957. This is a decrease of 83 percent over a 23-year period.

Spring chinook salmon runs fluctuated periodically since 1938 (Figure 1). The sharp drop in the late 1950's reflects the impact of McNary and The Dalles dams. The increase in the early 1970's reflects new hatchery production. The sharp downward trend since 1972 reflecting increased dam construction and powerhouse expansion reached an all time low of 51,000 fish in 1979.

Most sockeye salmon are bound for the last major production areas in the upper Columbia River above Priest Rapids Dam. The counts of 50,000 fish in 1979 and 1980 are only about one-half that needed for escapement. The last commercial sockeye salmon season was allowed in 1972. The run is composed of wild fish and the outlook is not good without assistance for the return of harvestable runs. Since 1938, the highest number of fish counted was in 1947, 335,000 fish (Figure 2). However, since 1953, the count has decreased

Table 1. Estimated Numbers (in thousands) of Upriver Salmon and Steelhead 1/ Entering the Columbia River 1938 - 1979

Year	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Summer Steelhead	Coho 2/
1938		123	516	168	250	15
1939	152	192	480	125	232	14
1940	90	113	558	196	423	12
1941	108	106	678	174	337	18
1942	77	95	627	94	297	12
1943	131	57	447	73	216	6
1944	56	67	596	25	232	4
1945	83	53	566	11	268	1
1946	124	72	670	101	268	4
1947	186	86	761	335	262	11
1948	126	87	682	143	240	4
1949	138	58	446	53	162	1
1950	120	69	469	113	179	10
1951	206	116	333	204	244	5
1952	246	114	242	319	383	8
1953	229	95	213	260	361	13
1954	189	115	192	180	290	4
1955	281	148	232	245	299	4
1956	217	195	298	202	201	6
1957	253	207	252	147	230	5
1958	198	187	328	313	211	4
1959	138	170	274	271	232	3
1960	134	143	230	179	200	3
1961	162	129	206	58	228	4
1962	200	108	245	39	252	15
1963	147	100	207	65	229	13
1964	169	97	280	105	179	54
1965	176	82	304	55	227	76
1966	175	75	268	169	209	72
1967	151	101	308	165	167	96
1968	134	89	210	135	162	63
1969	216	106	341	76	172	49
1970	171	73	359	85	138	80
1971	168	90	296	150	225	76
1972	281	77	235	123	226	66
1973	233	49	318	61	188	55
1974	108	34	238	44	145	61
1975	104	44	374	58	84	58
1976	78	42	359	44	122	53
1977	144	41	275	100	196	19
1978	129	43	240	18	105	53
1979	51	34	220	53	114	45

1/ Destined above Bonneville Dam
2/ Bonneville Dam Count

Figure 1. Estimated Numbers of Upriver Chinook Salmon in Runs Entering the Columbia River, 1938-80, and Major Dams in the Columbia System by Year of Completion.

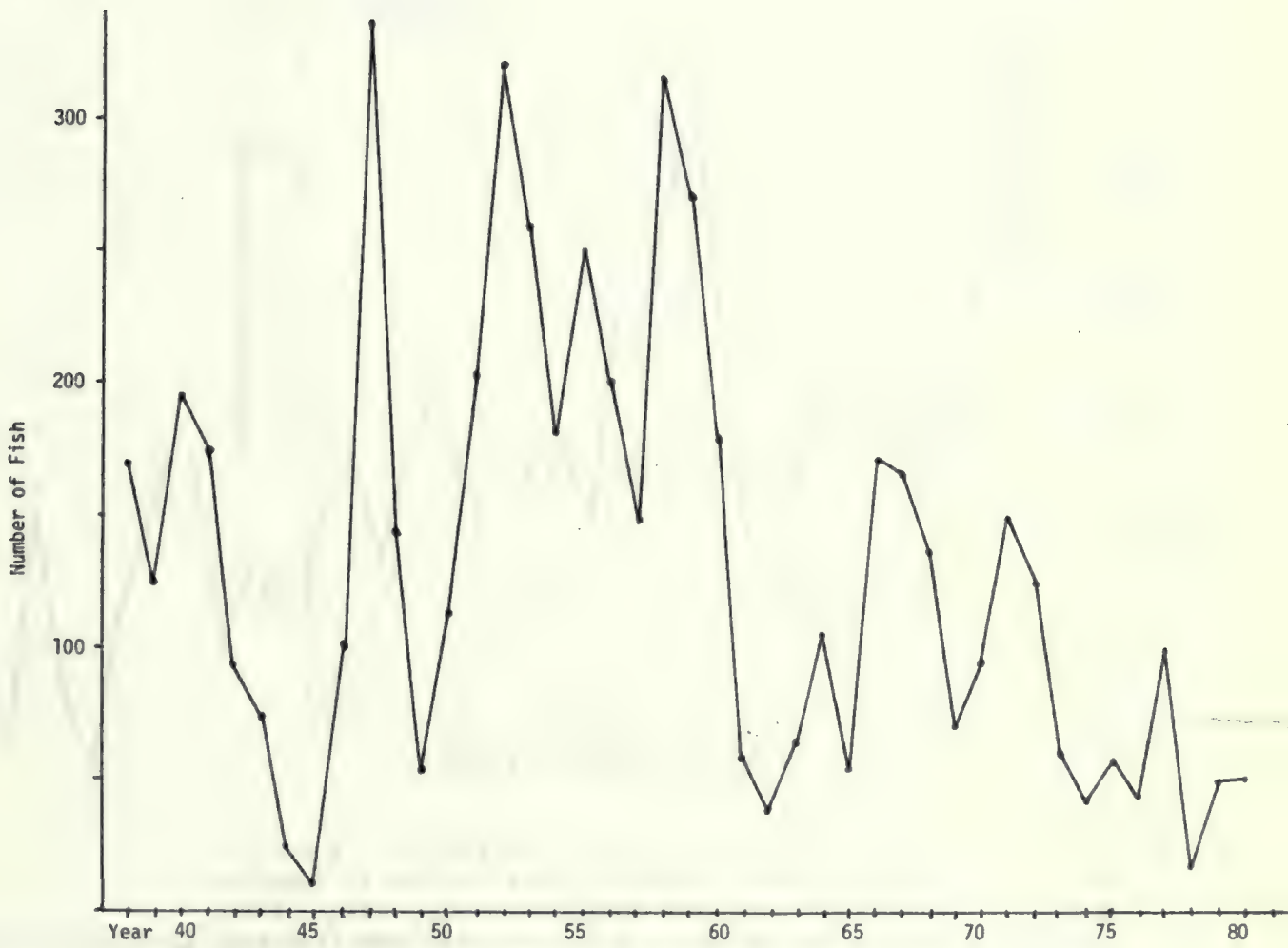

Figure 2. Estimated Numbers of Sockeye Salmon Entering the Columbia River, 1938-80.

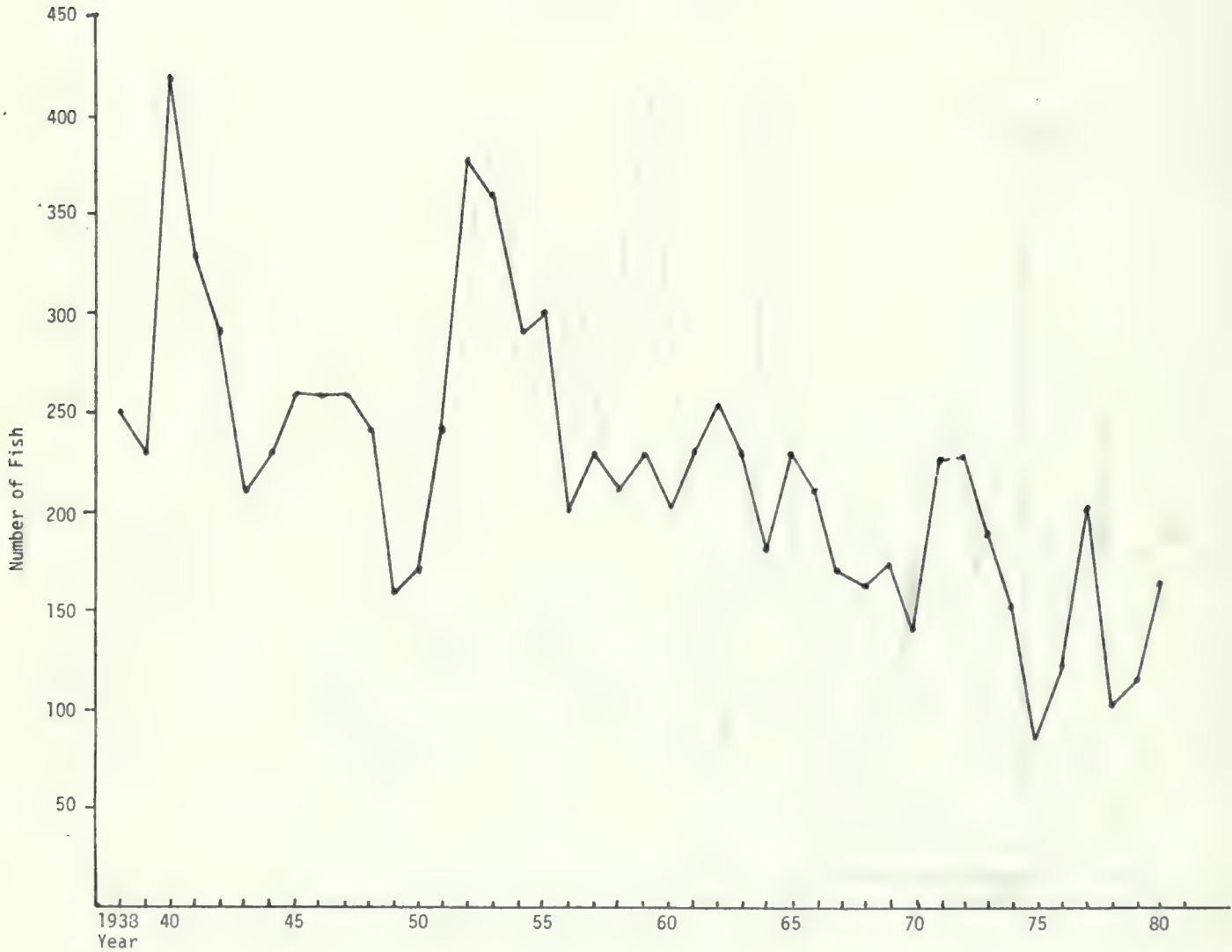

Figure 3. Estimated Number of Upriver Summer Steelhead Entering the Columbia River, 1938-80.

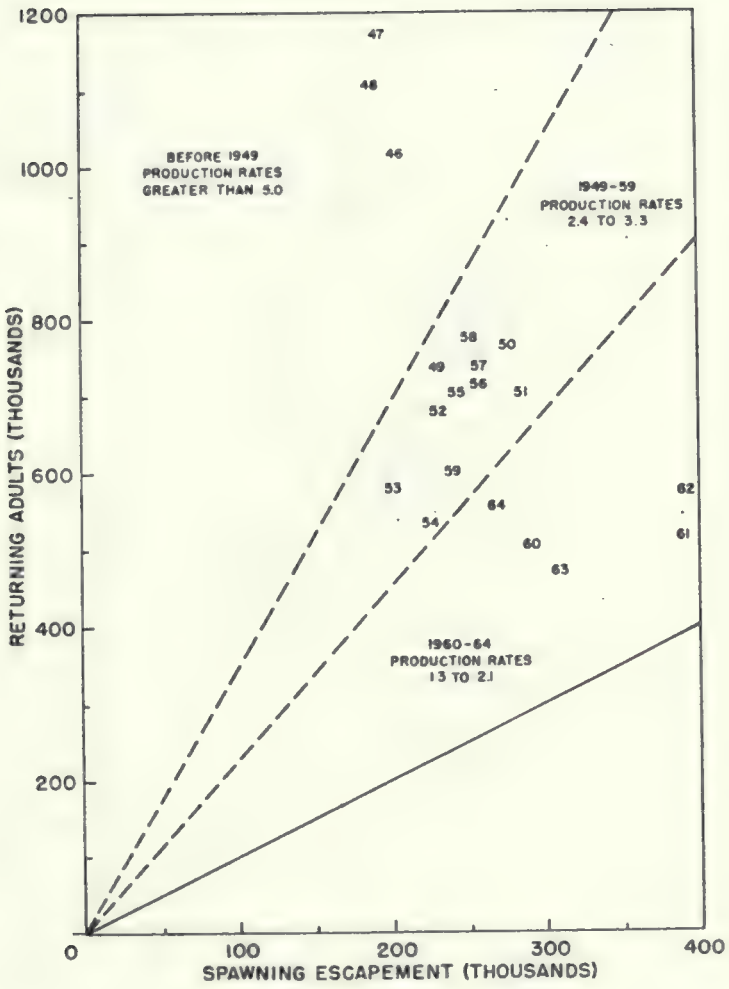

Figure 4 - Production rates of Columbia River chinook salmon for runs returning from 1946 to 1964. Data include combined spring, summer, and fall runs.

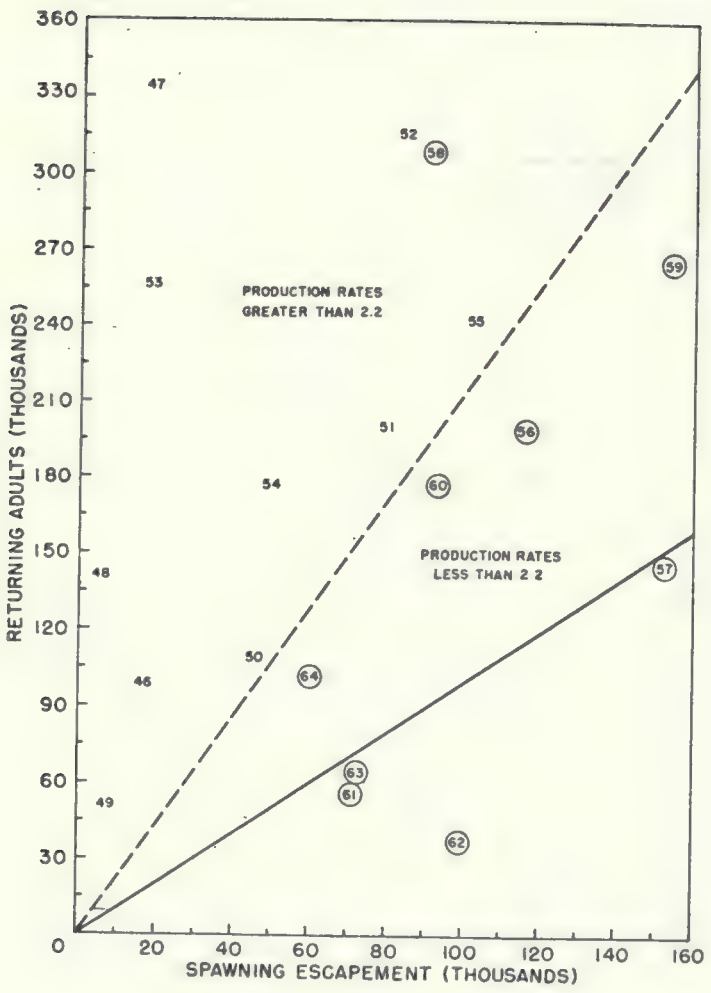

Figure 5 - Production rates of Columbia River summer run steelhead from 1946-64. Runs after 1955 circled.

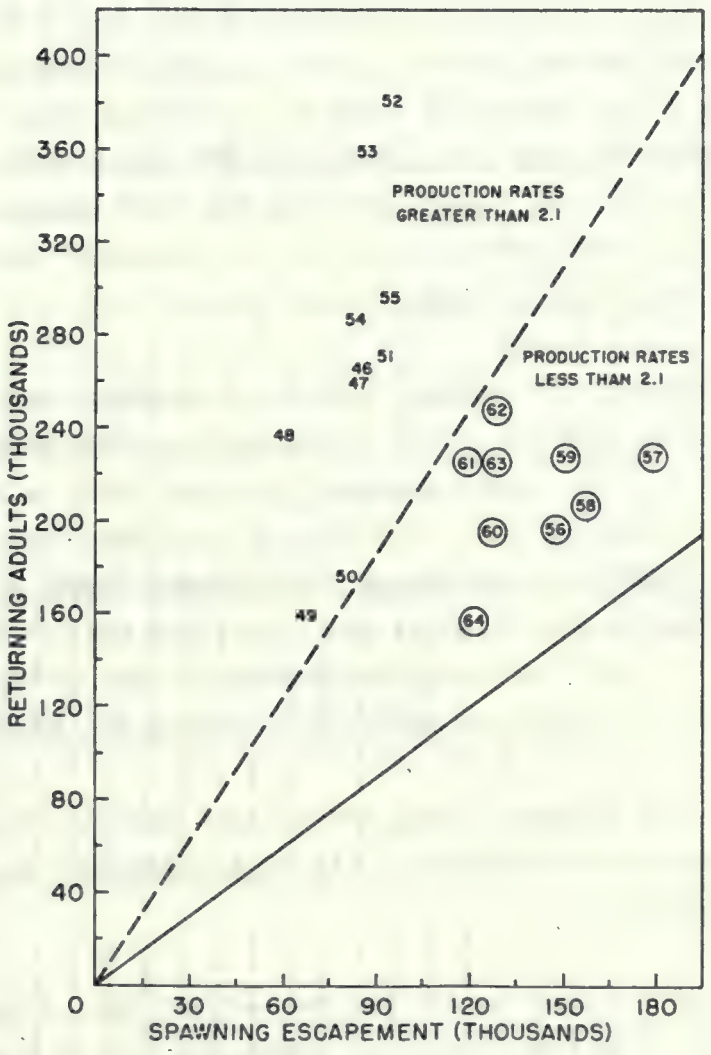

Figure 6 - Production rates of Columbia River sockeye salmon from 1946-64. Runs after 1955 circled.

decidedly. The 1980 run of 50,000 fish represents only 19 percent of the 1953 run and is only 38 percent of the 43-year average.

Summer steelhead trout enter the lower Columbia River from April through October with peak abundance levels in late June through early September.

As with the summer chinook salmon, summer steelhead runs have fluctuated and show a steady downward trend in numbers of fish. A high of 420,000 fish was estimated in 1940 and a low of 84,000 fish in 1975. The 1979 upriver summer steelhead run of 114,000 fish was the third smallest since 1938. Between 1940 and 1979, a 40-year period, the estimated runs have decreased by 276,000 fish or 73 percent.

For coho salmon the potential of a salmon resource to increase even with dams is demonstrated. Piror to 1960 runs were depressed but with utilization of hatcheries and habitat the runs were increased to a high count of 96,000 at Bonneville Dam in 1967. During the 1970's upriver coho runs began to decrease as hatchery production was directed to releasing smolts below Bonneville Dam thus maintaining the lower river runs and harvest in the ocean and lower river. Coho fisheries above Bonneville Dam no longer exist and only minor numbers are harvested incidentally during the fall fishery.

In short, the runs of chinook, coho, and sockeye salmon and summer steelhead trout have decreased measurably. In most instances, the runs have dropped at least 50 percent.

These decreases are evident despite greatly reduced fishing seasons and harvests of the species. The Columbia River commercial fishing seasons below Bonneville have been reduced from over eight months per year in the early 1940's to about 82 days per year in the early 1970's (Figure 7) and only 43 days in 1979. The offshore Oregon sport fishery has been reduced from a year-round fishery to little more than four months. The three-fish limit has been reduced to two fish. These changes have occurred over only a four-year period (Figure 8). The Oregon offshore commercial chinook fishery has declined from a period of no restrictions prior to 1948 to little more than a three-month season off the Columbia River mouth in 1979 (Figure 9).

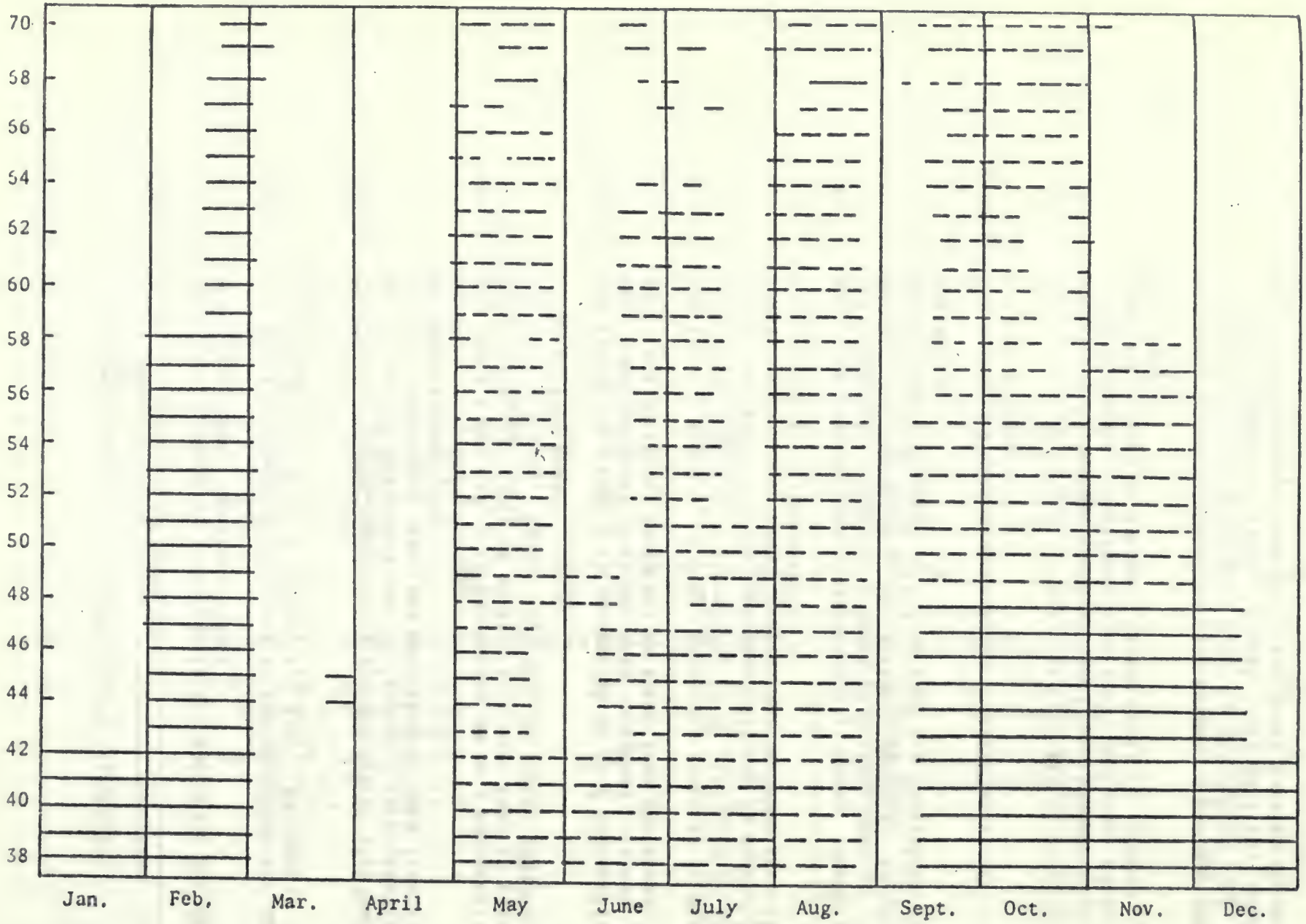

Figure 7. Columbia River Commercial Fishing Seasons Below Bonneville Dam, 1938-70 (Lines indicate open periods)

Figure 8. A Chronology of Oregon Ocean Salmon Sport Regulations

Years	Regulations
1946	Bag limit 3 salmon or steelhead in the aggregate per day; 9 in possession. No annual limit.
1947	Bag limit 2 salmon or steelhead in the aggregate per day; 6 in possession or in 7 consecutive days. No annual limit.
1948-55	Bag limit 2 in the aggregate in any one day of steelhead and salmon 20 inches and over in length; 4 in possession or in 7 consecutive days; not more than 20 such fish in any one calendar year.
1955-64	Bag limit 2 per day, 4 in possession or in 7 consecutive days and annual limit of 40 fish (not more than 20 salmon and 20 steelhead). Salmon less than 20 inches could not be taken from ocean.
1965-69	Bag limit 3 per day, 6 in possession or in 7 consecutive days. Annual limit 20 salmon - 20 steelhead. Salmon less than 20 inches could not be taken from the ocean.
1970-75	Bag limit 3 per day, no 7-day possesion limit as in past, annual limit 40 fish. (40 salmon or 40 steelhead or an aggregate catch of salmon and steelhead not to exceed 40 fish). Salmon less than 20 inches may be taken from the ocean south of Tillamook Head.
1976	Bag, possession and annual limit same as above. North of Tillamook Head chinook size limit 24 inches, coho 16 inches. No size limit south of Tillamook Head. Season May 1 through December 31 (first time any limitation on season).
1977	Bag and size limits same as above. Season April 30 through October 31.
1978	Bag limit same as above. North of Cape Falcon chinook size limit 24 inches, south of Cape Falcon chinook size limit 22 inches. Coastwide size limit for coho, pink, chum and sockeye 16 inches. Season April 29 through October 31.
1979	Bag limit 2 per day south of Cape Falcon, 3 per day north of Cape Falcon of which only 2 may be chinook or coho. No 7-day possession limit. Annual limit 40 fish. Season May 12 through September 16. Size limit same as above.

Figure 9. HISTORY OF OREGON TROLL REGULATIONS

Year	CHINOOK		COHO	
	Season	Size	Season	Size
Prior to 1948	No Restrictions	No Restrictions	No Restrictions	No Restrictions
1948	No Restrictions	27"	July 1 - November 15	same
1949 - 1955	March 15 - October 31	26"	June 15 - October 31	same
1956 - 1964	April 15 - October 31	same	same	same
1965 - 1975	same	same	same	15"
1976	North of Tillamook Head May 1 - June 14 and July 1 - October 31	28" until 6/4/76 26" after 6/4/76	North of Tillamook Head July 1 - October 31	16"
	South of Tillamook Head May 1 - October 31	26"	South of Tillamook Head June 15 - October 31	
1977	same	28" N. of Till. Head 26" S. of Till. Head	same	same
1978	Boundary moved south to Cape Falcon - same dates and size limits as 1977.			
1979	North of Cape Falcon May 1 - May 31 and July 1 - September 8	28"	North of Cape Falcon July 1 - September 8	same
	South of Cape Falcon May 1 - May 31 and July 1 - October 31	26"	South of Cape Falcon July 1 - September 15	same

SPECIAL SOUTH COAST TROLL SEASONS OFF CHETCO AND ELK RIVERS

1974 - 1975	November 1 through December 31

The magnitude of the decrease in the Zone 6 commercial Indian fishery is also significant. Tribal ceremonial and subsistence fisheries have been so curtailed on both the mainstem and tributaries as to be nearly non-existent. These trends must be reversed to once again provide productive Indian fisheries as reserved by their treaty rights.

CHAPTER F

Overview of the Goal, Objectives, Subobjectives, and Tasks

CHAPTER F
OVERVIEW OF THE GOAL, OBJECTIVES, SUBOBJECTIVES, AND TASKS

Framework of the Recommendations

Chapters 1 through 6 comprise the heart of the recommendations for the protection, mitigation, and enhancement of anadromous fishery resources, including supporting habitat. As noted previously, the recommendations are based on a single Goal statement and six Objectives. The first four Objectives are biological, while the last two are institutional in nature. Each Objective has been divided into Subobjectives, and each Subobjective has been further divided into project-specific Tasks as appropriate. Through the Goal and Objectives, the recommendations reflect the system-wide approach to anadromous fishery problems contemplated by the Power Act. Through the more specific Subobjectives and Tasks, the recommendations direct attention to fishery measures at and between power facilities, in a logical progression from system needs to requirements for individual facilities.

Supporting Material for the Recommendations

The Goal, Objectives, Subobjectives, and Tasks are accompanied by a supporting discussion. In keeping with the intent of the Power Act, the supporting discussion generally explains the problem and current situation affecting anadromous fish, the rationale for the recommendation, and citations to scientific publications as appropriate. The recommendations are based on and supported by the "best available scientific knowledge" of the fishery agencies and Indian tribes, taking into account scientific research data, general understandings inferred from such data, biological opinion based on field observations and experience, and the urgency of the condition of particular anadromous fish runs. Additionally, the recommendations reflect the fishery agencies; and tribes' views on measures which may realistically be implemented given a balance between protection, mitigation, and enhancement of anadromous fisheries and an adequate efficient, economical, and reliable power supply.

In cases where the "best available scientific knowledge: is limited, the recommendations provide closely circumscribed proposals for further research in lieu of or to supplement specific fishery measures. Research proposals are designed to develop or refine specific fishery measures as expeditiously as possible.

In this regard, some further comments are warranted on the relationship between the recommendations and research data. It must be recognized that the collection and analysis of precise and undisputed data on biological populations in nature are extremely difficult, and in some cases virtually impossible. Scientists commonly analyze research results by statistically requiring 90-95 percent confidence prior to accepting or rejecting a hypothesis, a confidence level that may be difficult to achieve outside of the laboratory.

Anadromous fish populations are subject to numerous environmental parameters in three major ecosystems--freshwater river, estuary, and marine. It is not only difficult to identify all parameters that influence the survival and abundance of anadromous fish, but nearly impossible to quantify the exact effect of each. Evaluations of some parameters may require detailed and expensive research that may take years to complete; evaluation of other parameters may simply not be possible or practicable. The Oregon Department of Fish and Wildlife has stated that,

> ...studies of (salmonid) survival or abundance may require 20 to 30 years just to produce an 80 percent chance of detecting a 50 percent change, while studies of time and size at important life history stages require 8 to 10 years to provide an 80 percent chance of detecting a 5 to 15 percent change...small or even moderate effects on abundance resulting from man's activities added to the myriad of natural factors determining abundance require several years of extensive sampling to detect.
> [Licat[illegible]ch and Cramer, 1979]

Even with 30 years of extensive research into anadromous fish problems in the Columbia River Basin, the conclusions drawn from this research have still been subject to dispute and argument by fishery and power interests. In many cases further research may provide more data, but will not significantly alter overall research results, and cannot be expected to alleviate or eliminate arguments on the conclusions drawn from research. Moreover, future research is strictly limited by the numbers of available fish. Fish used in research always suffer certain handling mortalities, which may not be acceptable when remnant runs are involved. Similarly remaining fish populations may not be large enough to supply necessary sample sizes for studies which will be statistically reliable.

Measures to protect, mitigate, and enhance anadromous fisheries must be based on sound scientific knowledge, but cannot await research which will precisely quantify all cause and effect parameters influencing fish populations. The parameters influencing anadromous fish are simply too numerous and the populations themselves are simply too dynamic for precise quantification. Essentially, anadromous fish populations are being depleted more rapidly than depletion can be assessed and quantified.

In view of the depleted condition of upriver runs and the limitations of further research, priority must be placed on implementation of protective measures accompanied by research to monitor and refine these measures.

Terminology

The Power Act directs the "protection," "mitigation," and "enhancement" of anadromous fishery resources. As used in the Act, "protection" is generally understood to mean the conservation and preservation of habitat and populations; "mitigation" is generally understood to mean reducing avoidable losses and compensating for unavoidable losses; and "enhancement" is generally understood to mean improvements beyond mitigation, here as a form of "off-site" mitigation.

In the discussion of the Goal, Objectives, Subobjectives, and Tasks, the fishery agencies and tribes have used slightly different but more precise

terminology. Here, "protection" and "enhancement" have the same meaning generally applied to the terms under the Power Act. However, the term "mitigation" as used in the Act has been divided into two components. "Mitigation" is used solely to refer to efforts to reduce all avoidable fishery losses, while the term "compensation" is used to refer to efforts to address fishery losses which are unavoidable (e.g., habitat losses directly attributable to dam construction, unavoidable passage mortalities). In accordance with this distinction, mitigation precedes and is the preferred alternative to compensation, and compensation will only apply to losses which cannot be mitigated.

CHAPTER G

Anadromous Fishery Goal and Explanation and Justification of Fishery Production Goals

CHAPTER G

ANADROMOUS FISHERY GOAL

TO PROTECT, MITIGATE, AND ENHANCE FISH AND WILDLIFE AND RELATED SPAWNING GROUNDS AND HABITAT TO THE EXTENT AFFECTED BY THE DEVELOPMENT AND OPERATION OF ANY ELECTRIC POWER FACILITY ON THE COLUMBIA RIVER AND ITS TRIBUTARIES IN A MANNER CONSISTENT WITH P.L. 96-501 AND OTHER APPLICABLE LAWS AND TREATIES

Implicit in the Anadromous Fish Goal is a determination of the effects of electric power development on upriver salmon and steelhead runs (those destined above Bonneville Dam), and what anadromous fish production levels should be attained to remedy the impacts of electric power development in the Columbia Basin. This determination must be biologically sound, legally supportable, economically and socially valuable, and consistent with Indian treaty rights and other applicable law.

Based on these considerations, the fishery agencies and Indian tribes have determined that the Goal of the Northwest Power Planning Council's Fish and Wildlife program should be restoration of upriver anadromous fish production levels approximating those that could have reasonably been maintained prior to the era of extensive mainstem power development initiated by construction of McNary Dam in 1953. This period of expansion (1953 - late 1970's) saw the Columbia Basin's installed hydroelectric capacity increasing from about 3,500 megawatts to 23,000 megawatts as shown in Figure 1.

The Goal is subject to certain exceptions based on Indian treaty obligations. For example, coho production levels are based upon the success of increasing runs in the 1960's and not on passage mortalities on a base run.

Establishing a Goal of pre-McNary Dam production levels is extremely conservative from a fisheries perspective, since considerable losses of anadromous fish from power installations occurred prior to 1953. In the pre-McNary period, Grand Coulee Dam as well as Black Canyon and other tributary dams were responsible for eliminating access to about 50 percent of

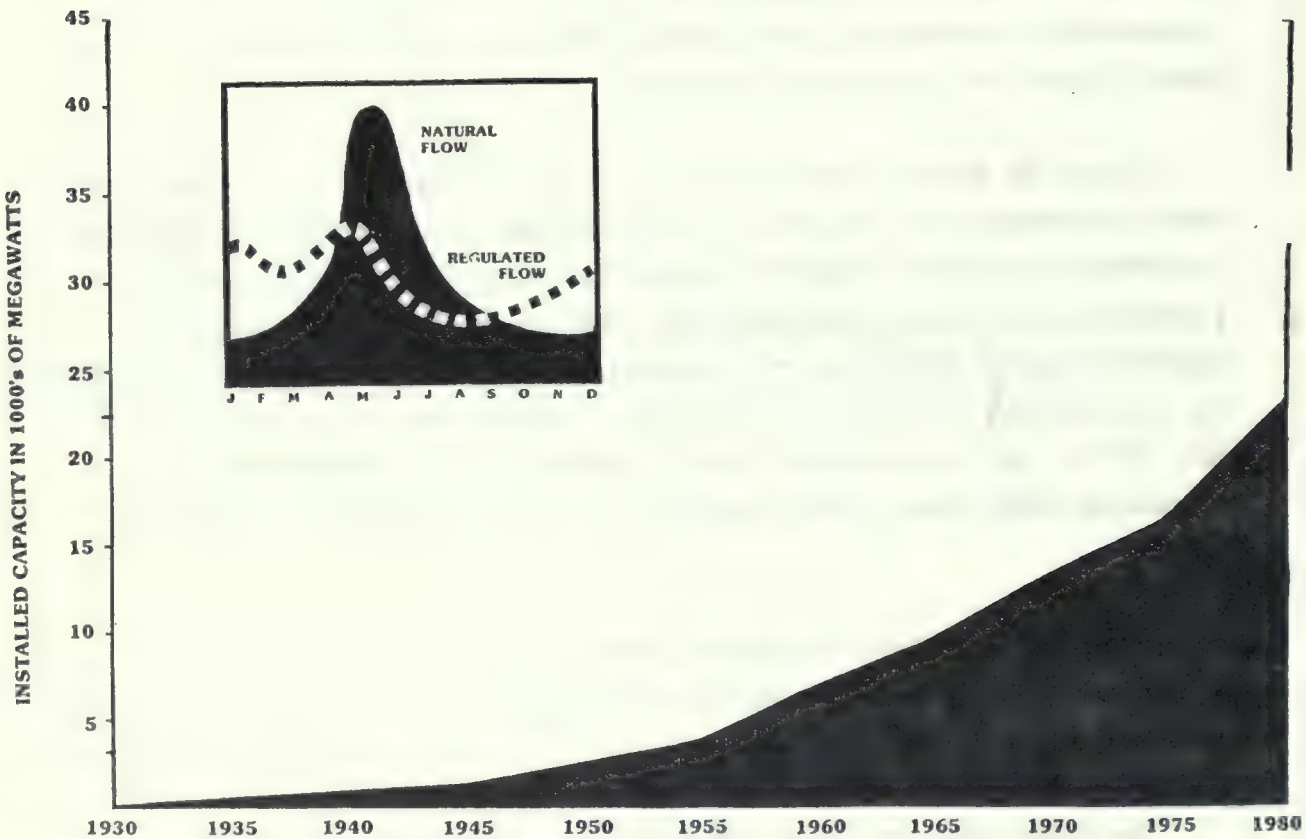

Figure 1. Generalized trend in Columbia River Basin installed generating capacity, 1930-1980. Inset illustrates generalized effect of reservoir operations on main stem Columbia River flows in vicinity of The Dalles, Oregon. (Columbia River Fisheries Council, 1981)

the Basin's anadromous fish habitat. Additionally, Rock Island and Bonneville Dams, constructed in the 1930's were responsible for adult and juvenile passage losses. These power developments did cause extensive losses of overall fish production and resulting harm to sport, commercial, and Indian treaty fisheries.

A goal to restore anadromous fishery production to levels which would have existed prior to all electric power facilities is legally supportable. Nevertheless, the fishery agencies and tribes recognize that such a goal might not be realistically achievable. In order to balance the protection, mitigation, and enhancement of anadromous fish resources with an adequate, economic and reliable power supply, an interim Goal equal to the pre-McNary Dam production levels for chinook, sockeye, and steelhead and 1967 coho run size was determined to be appropriate. This compromise determination reflects economic rather than biological considerations in keeping with the mandate of the Power Act.

A paper prepared for the Columbia River Fisheries Council (Junge, 1980) estimated compensation required to restore runs to levels that could have been maintained in the early 1950's ("pre-McNary"). That development assumes that combined adult and juvenile mortalities can be reduced to an average of 15 percent for each mainstem dam on the Snake and Columbia rivers in conjunction with the Lower Snake River Fish and Wildlife Compensation Plan which was based on a 15 percent level. Consequently, each dam in the system was assessed at this rate. Much of the following development is excerpted from that paper. For example, the definition of base runs is reproduced here directly, although justification of the detailed distribution by tributary is not given here. Further, the following development merely involves a first phase of our recommendations to the Power Planning Council. Under Phase I it is suggested that:

1. Bypass systems be installed at all mainstem Columbia and Snake river dams to minimize mortalities to adult and juvenile migrants.

2. Compensation at the rate of 5 percent per dam be initiated concurrently.

Phasing the development in this manner is advisable for the following reasons:

1. Status of the fish runs demands hatchery compensation as soon as possible.

2. Estimating passage losses at each dam is very costly and time consuming and even a system-wide estimate would not be necessary until after completion of Phase I, particularly the bypass systems.

3. The phase approach should minimize expensive hatchery compensation since it places primary empahsis on improving passage survival.

4. Experts familiar with bypass facilities agree that passage losses are unlikely to be reduced to less than 5 percent per dam. Thus, overcompensation is not possible.

5. Development of hatchery sites for full compensation will be difficult and time consuming.

BACKGROUND

Although the once great runs of salmon and steelhead in the Columbia River have been seriously decimated by hydroelectric projects on the Columbia and Snake rivers and their tributaries, efforts are currently underway to reverse this trend. Techniques are being developed to reduce mortalities on both juvenile migrants and adult migrants. The Corps of Engineers has installed spillway deflectors at many of their dams to reduce high nitrogen levels and incidence of gas bubble disease. They are also developing bypass systems, including transportation, to further reduce mortalities to migrants. Modifications of fishways are also being considered to improve upstream passage of adult migrants. It is assumed that vigorous application of such present-day techniques can reduce combined adult and juvenile mortalities to an average of 15 percent or less per dam. The goal of the fisheries agencies is to improve fish passage to achieve these reduced mortality levels and concurrently to initiate compensation for the remaining mortality. Ultimately,

however, the goal is to reduce juvenile and adult losses further as better technology becomes available.

At the present time no significant compensation in the form of returning adult salmon and steelhead has been received for mortalities to juvenile migrants, although the Lower Snake Compensation Plan currently funded and underway addresses this problem. Previous compensation, though substantial, is either for total destruction of segments of salmon and steelhead runs (a consequence of Idaho Power Company projects on the Snake River) or for flooding out spawning and rearing habitat (a consequence of several Columbia River projects). Remaining to be considered are mortalities to migrants passing all of the mainstem Columbia River dams.

There are two main components in the estimating procedure for defining compensation:

1. Establishment of a "base run size" or production goal that could have been maintained if the project or projects had not been constructed, and

2. Establishment of a mortality rate due to the passage over the project or series of projects.

Adults to be produced as compensation can then be estimated as the product of the mortality rate and the base run size.

Under the above formulation, it is assumed that production is replaced in kind by the species and stock impacted by the dam or dams and that replacement occurs in the general area of original production. Releasing smolts below a series of dams, though reducing total mortality, would introduce even more serious impacts on upriver fisheries. Although decisions to allow species substitutions or area changes by the fisheries management entities are not ruled out, effects of any such changes would have to be further evaluated and addressed with appropriate compensatory measures.

RECOMMENDED PRODUCTION GOALS

The present evaluation is only concerned with passage mortalities due to mainstem Columbia River dams and reservoirs. Losses related to the complete destruction of fish runs such as those due to Idaho Power Company dams on the middle Snake River or the effect of John Day Dam on a spawning population of fall chinook are only considered here to establish base run sizes.

Theoretically, complete restoration may be attained by eliminating mortalities completely (mitigation) or replacing all the losses (compensation). Actually it is unlikely that either one of these options could work exclusively of the other, and attempts to do so could be inordinately costly. The phased approach suggested here and illustrated in Figure 2 should allow the best blend of mitigation and compensation so that harvestable runs can be restored in a timely manner and with minimal costs.

Phase I involves two programs to be conducted concurrently:

(1) Installation of effective juvenile bypass systems and improvement in adult passage systems at all mainstem Columbia and Snake River dams. This is shown as Phase I (Primary) in Figure 2.

(2) Compensation for passage losses at the rate of 5 percent per dam. This is shown as Phase I (Secondary) in the figure.

Phase II would involve completion of the hatchery compensation program as indicated by the average mortality per dam after bypass facilities are completed and evaluated. Table 1 summarizes the compensation requirements under Phase I and for example, the requirements if eventual passage mortalities average 15 percent per dam.

BASE RUN SIZE

If compensation estimates are made sequentially for different projects with sequentially reduced "base runs" because of delayed compensation, then complete restoration by compensation would be impossible. The liability of later projects would be reduced because of the decimation by the earlier

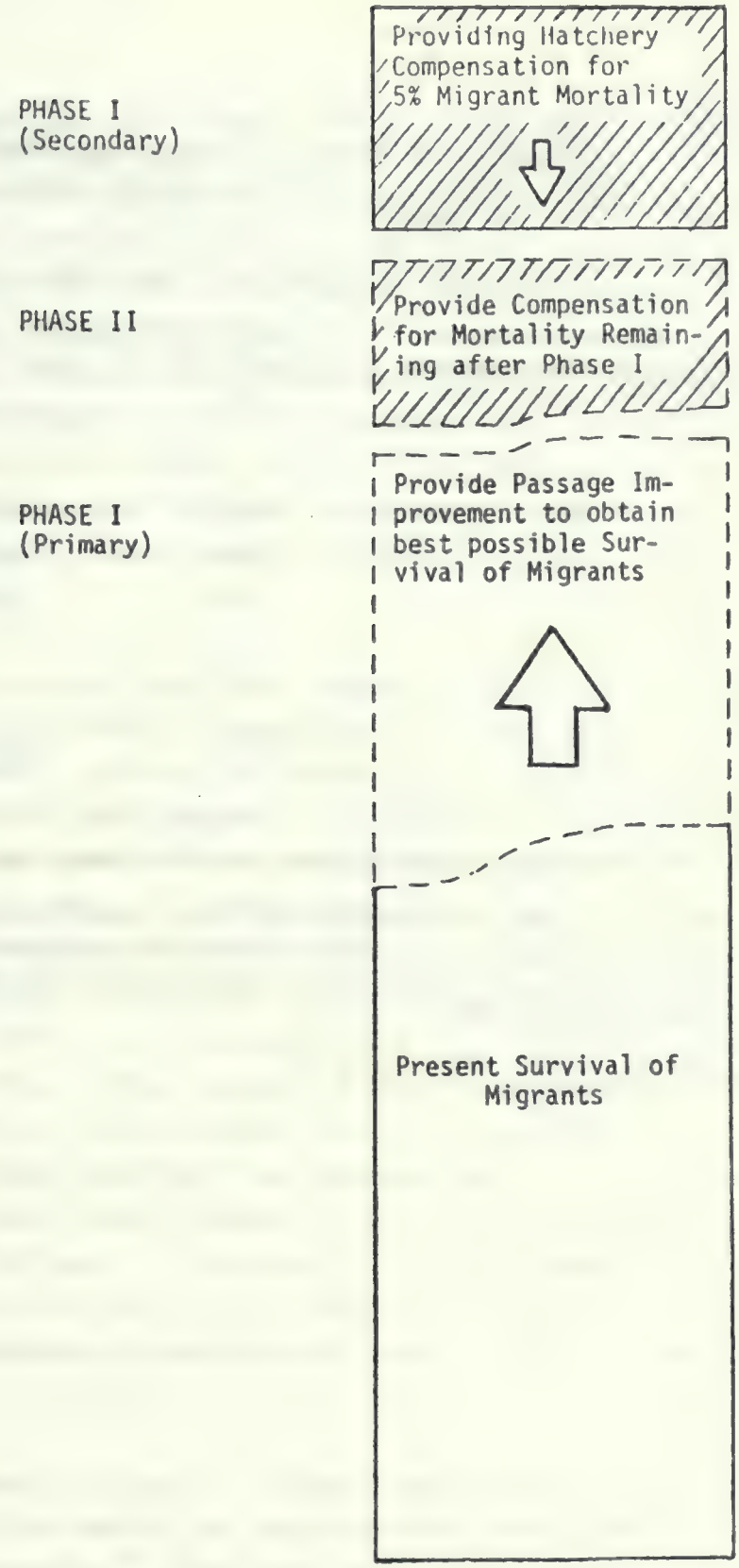
PHASE I
(Secondary)
Providing Hatchery Compensation for 5% Migrant Mortality
PHASE II
Provide Compensation for Mortality Remaining after Phase I
PHASE I
(Primary)
Provide Passage Improvement to obtain best possible Survival of Migrants
Present Survival of Migrants

Figure 2. Conceptual approach to phasing passage compensation.

Table 1. Adult Return to the Columbia River Required to Compensate for Passage Losses under Phase I with 5% Mortality Per Dam and Under Phase II If a 15% Mortality Per Dam Results

	Adult Returns Required for Compensation (1,000's)			
	With 5% Mortality Per Dam For All Columbia River Dams 1/	With 15% Mortality per Dam 3/		
		Columbia R. 1/	Snake R. 2/	Total
	(1)	(2)	(3)	(4)
Chinook				
Springs	54.3	121.5	74.8	196.3
Summers	44.9	97.3	48.8	146.1
Falls	56.5	143.0	33.8	176.8
Sockeye	68.4	147.3	--	147.3
Summer Steelhead	66.7	150.8	105.3	256.1

1/ Includes five PUD dams on mid-Columbia and four Corps dams on lower Columbia.

2/ Mortalities and compensation due to four Corps dams on Snake River have already been addressed in Lower Snake River Compensation Plan. Values here are consistent with Lower Snake River Compensation Plan which was also based on a 15% mortality per dam.

3/ Reproduced from Junge, 1980, Table 6.

projects. In estimating the pre-McNary base run levels, rather than using average run levels, it was determined in the Lower Snake Compensation Plan, in 1979-1980 hearings before the Federal Energy Regulatory Commission (FERC) relative to Idaho Power Company compensation, and in mitigation and compensation for the Corps of Engineers' proposed McNary Second Powerhouse Project, that maximum run size during this period was proper. As may be noted in the following development, maximum run size during this period gives a conservative estimate of the run size that could have been maintained had the mainstem dams not been constructed. Appendix B of the Corps of Engineers' Lower Snake River Compensation Plan sets out this rationale in greater detail.

Counts of adult salmon and steelhead passing Bonneville Dam after its completion in 1938 made it possible for the first time to estimate both run size and escapement. Run size was defined as the Bonneville count plus the catch below Bonneville, and escapement was defined as the Bonneville count less the catch above Bonneville. The accumulation of such data in conjunction with the developing science of fisheries management led to the process of optimizing escapement levels to optimize production. In comparing production with escapements, there is clear evidence of overfishing in the late 1940's (FCO, WDF, 1971). As escapement levels were gradually increased in an attempt to define optimum escapement levels, run sizes also continued to increase until the construction of McNary Dam and The Dalles Dam (and the sequence of dams since that time) seriously lowered the production levels. Junge and Oakley (1966) (Figures 3, 4, and 6) illustrate these effects (see History of Fish Runs). Consequently, it is not proper to use average run levels from the late 1940's to the 1960's, most of which were depressed by inadequate escapements in the earlier years and later by the effects of the dams.

In Figures 3, 4, and 5, we have have reproduced portions of the figures referred to above for the run years preceding those severely depressed by the dam construction.[1/] For these years we have very roughly (one or two

1/ Run years impacted by the very severe 1948 flood were not plotted.

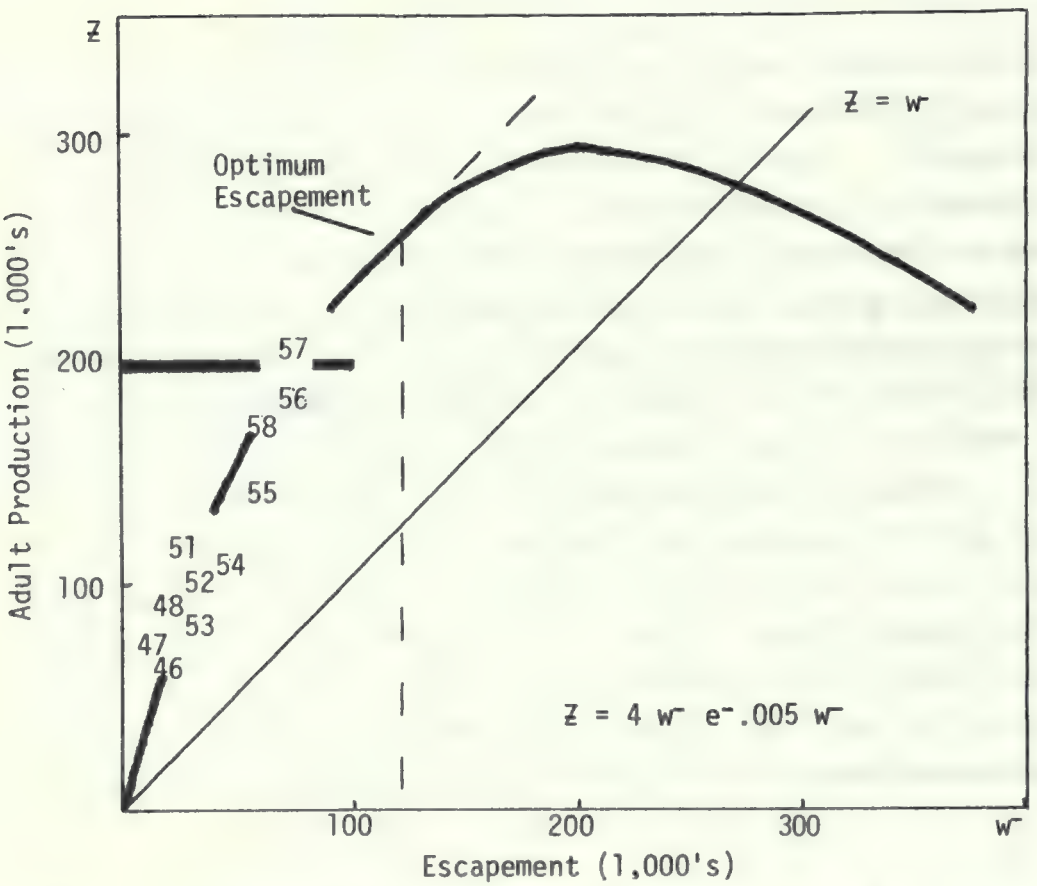

Figure 3. Ricker Reproduction Curves for Years Preceding Impact of Major Dam Construction (by year of Returning Run) for Summer Chinook Salmon (Junge, 1980).

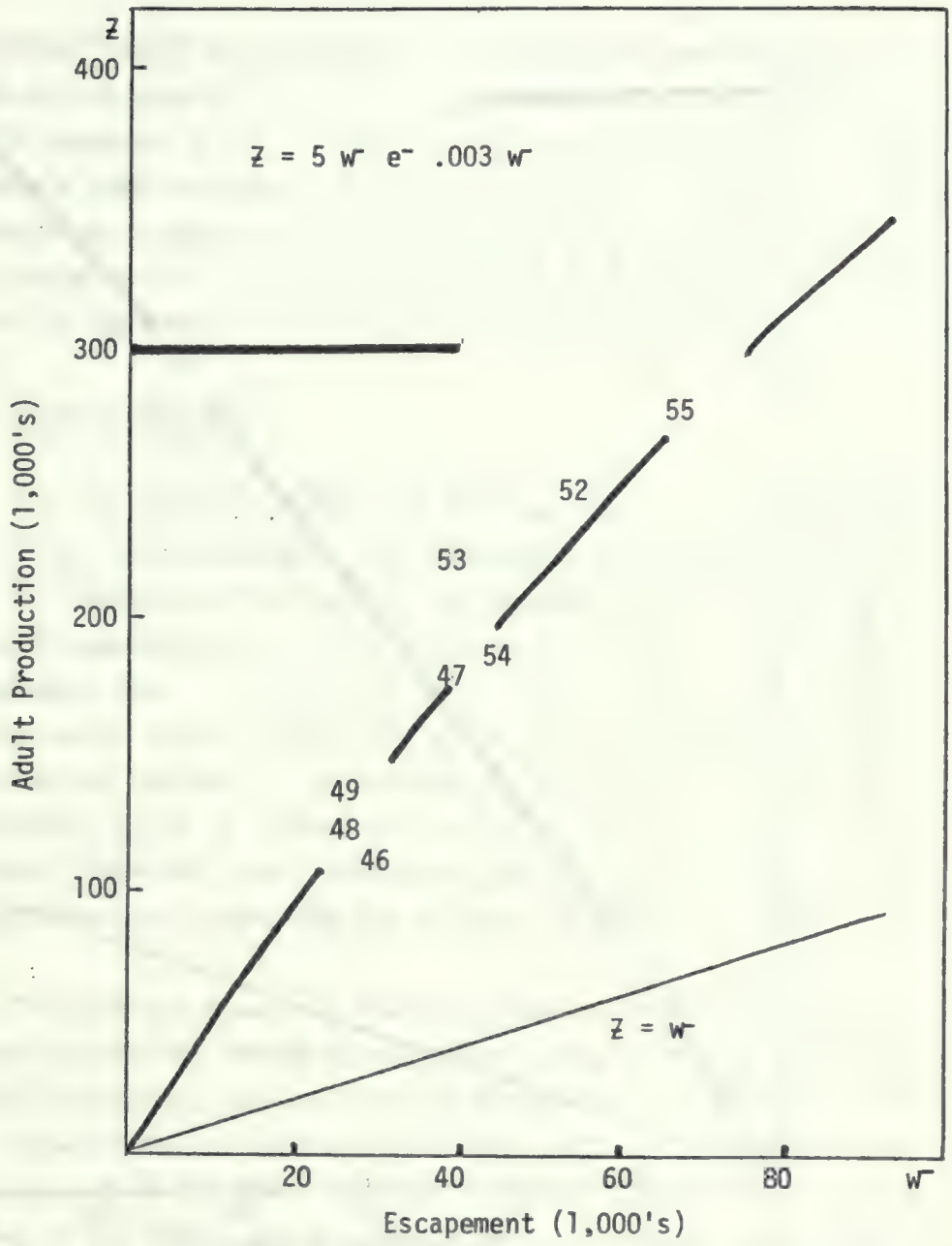

Figure 4. Ricker Reproduction Curves for Years Preceding Impact of Major Dam Construction (by Year of Returning Run) for Spring Chinook Salmon (Junge, 1980).

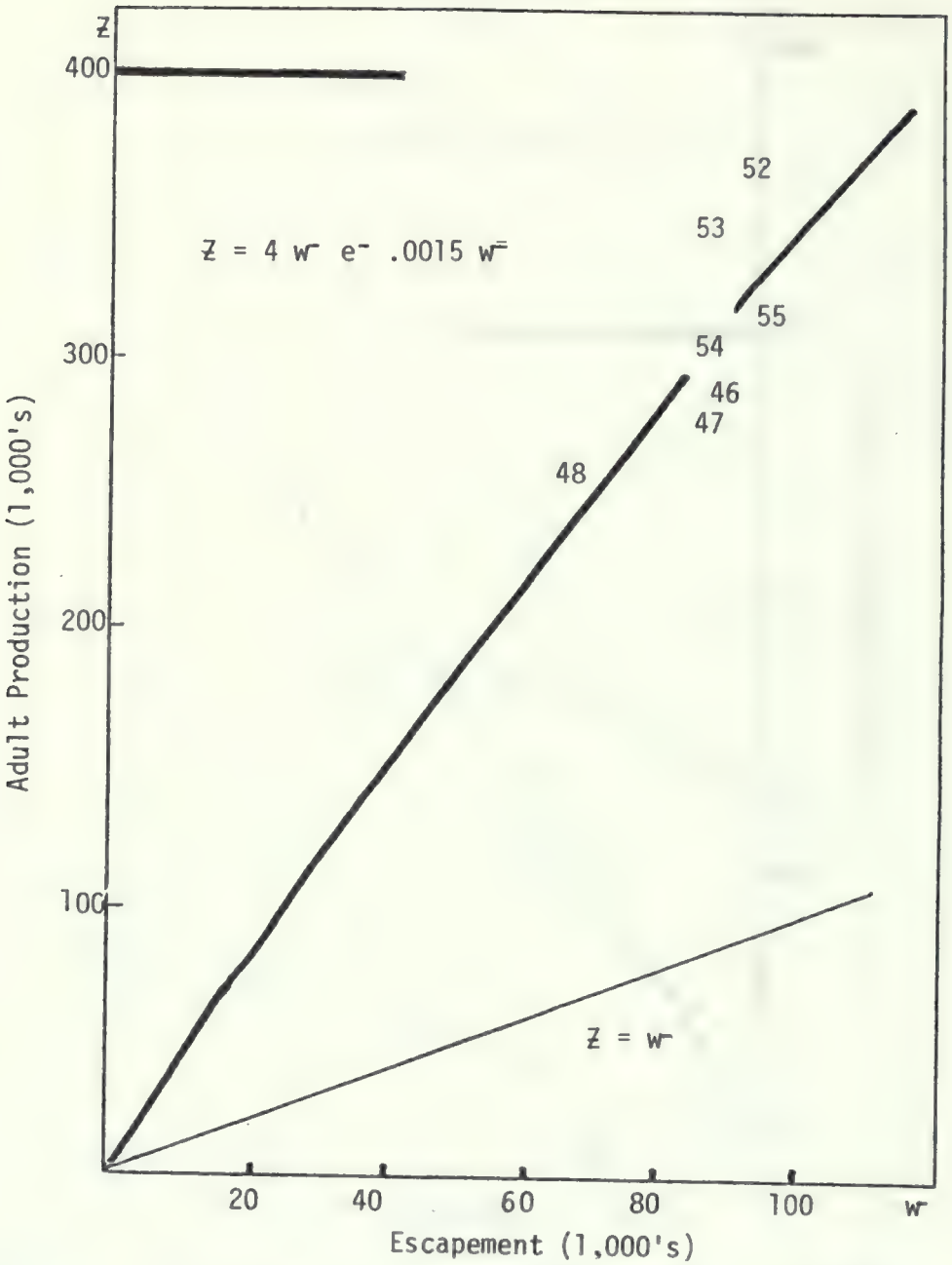

Figure 5. Ricker Reproduction Curves for Years Preceding Impact of Major Dam Construction (by Year of Returning Run) for Summer Steelhead (Junge, 1980).

significant digits in parameters) fitted Ricker's reproduction curves (Ricker, 1958) to the plot of run size or adult production (Z) against the escapement which produced it (w). These curves indicate the relationship between spawners and subsequent recruits and provide additional support for the use of maximum recorded run size as a basis. For summer chinook (Figure 3) we have equalized the scales for Z and w and extrapolated the Ricker curve merely to illustrate the standard technique for estimating optimum escapement.

Summer Chinook

For the summer chinook the 45° line, Z = w, represents the replacement level. For any escapement, the difference between reproduction curve and this line represents the average sustainable yield for that escapement. This is clearly maximized where the slope to the curve is parallel to the replacement line. As indicated in the figure, this would occur for an escapement of about 120,000 and produce a run of about 260,000. This would maximize the number to the fisheries at about 140,000. For sport fisheries, catchability which is related to availability is very important. Consequently, for sport fisheries, peak production (about 295,000 for an escapement of 200,000) may be considered the optimum condition.

The selected base run size and recommended production goal for summer chinook is 200,000. This corresponds to the estimated production for an 80,000 escapement, the goal set by Washington and Oregon biologists based on data collected in the 1950's (FCO, WDF, 1971). This is also very close to the maximum run of 207,000 returning in 1957. Virtually any compensatory curve plotted to the points would indicate that, on the average, a run in excess of 200,000 could have been maintained with increased escapements before the construction of McNary Dam.

Spring Chinook

For spring chinook, we have plotted only a portion of the ascending limb of the Ricker curve. Figure 4. The recommended base run size and

production goal of 300,000 corresponds to the estimated production from the 80,000 escapement goal for spring chinook in the late 1950's (FCO, WDF, 1971). This is also close to the run of 281,000 returning in 1955. In Figure 4, optimum production would be much greater than the base run level indicated by the limited data available. Nonetheless, the run estimate has been conservatively chose to remain close to the range of observed data.

Summer Steelhead

For summer steelhead only a portion of the scending limb of the Ricker curve again has been plotted, Figure 5. The recommended base run size and production goal of 400,000 corresponds to the estimated production from the 120,000 escapement goal for steelhead in the 1950's (FCO, WDF, 1971). This is also very close to the largest run of 383,000 returning in 1952. In Figure 5, optimum production again would be much greater than the base run recommended here.

Sockeye

Because of the extreme variability of sockeye production for all escapement levels (Junge, 1966), it is likely that the maximum run of about 320,000 in 1952 could not have been regularly maintained even with optimum escapement. This variability in sockeye population dynamics also does not allow examination of the sockeye runs through use of recruitment curves. However, as indicated for the other species, an average level for the 1950's 1951-59, excluding 1950 which was severely impacted by the 1948 flood) of 238,000 is undoubtedly low. Consequently, a conservative sockeye base run size of 250,000 sockeye would be applicable. However, since construction of McNary, part of this production capability has been reduced by loss of habitat in the Canadian section of the Okanogan River. The Washington Department of Fisheries estimates this loss at almost 50,000 fish (Tom Meekin, pers. comm.). This leaves a base run size and recommended production goal of 200,000.

Fall Chinook

Unlike most other anadromous fish runs of the late 1940's and early 1950's, a portion of the fall chinook run was of hatchery origin. This mixture of artificial and natural production invalidates the use of standard recruitment curves to estimate optimal escapement and production.

The basis for restoration of fall chinook is developed by adding the escapement levels to the various spawning areas in the Basin and the early hatchery escapements to the Bonneville pool area. This summation results in an escapement of 133,000 fish (Junge, 1980). Comprehensive hatchery contribution studies of fall chinook in the early 1960's show that for each escaping fish two were caught in the river fisheries and six in the ocean (Wahle, 1978). The base run size then is 400,000 (3 x 133,000) and is recommended as the restoration basis.

Coho

Coho salmon experienced increased runs during the 1960's because of increased hatchery production particularly in the Bonneville Pool area and utilization of habitat in the mid-Columbia and Snake River systems.

Coho restoration is based on the Bonneville Dam counts of 1967, 96,000, minus the Zone 6 tribal harvest, 14,000. The 1967 run demonstrated the ability to increase the run and is used as the base. Hatchery contribution studies of coho in the 1960's show that for each escaping fish seven are caught in the ocean fishery and in one in fresh water (Wahle, 1974). Therefore, the base run size is 164,000 (2 x 82,000) and is recommended as the restoration basis.

The eventual estimate of compensation would require supplementation of current runs to the mouth of the Columbia River with adults equal in number to the product of the base run size and the percentage mortality caused by the dams. Of course, if the rate of exploitation of the ocean fisheries should change from the rate occurring in the late 1950's or early 1960's, more (or less) adults would be required to be returned to the river, if respectively, the ocean fishing rate was reduced (or increased). Thus, altertion in the

division of the catch between ocean and river should not be attributed to the effects of power development.

Comprehensive marked (coded-wire tag) chinook studies currently underway (Vreeland 1979, 1980, 1981) when completed and compared to those of the early 1960's (Wahle, 1974,1978), should identify any significant change in the fishing rate and provide a basis for appropriate adjustments in the base run size. Ocean catches of steelhead and sockeye are insignificant so will not require adjustment. Table 2 summarizes the recommended production levels for the species of salmon and steelhead and compares them to current run levels.

MORTALITY RATES

Compensating at a rate of 5 percent per dam could only result in overcompensation if fishway facilities could reduce the average impact per project to less than 5 percent. The difficulty in reducing these mortalities to 20 percent, 15 percent, or 10 percent per dam should be apparent from studies conducted in the last 2 or 3 decades. Studies conducted by the National Marine Fisheries Service since the late 1960's (Raymond, 1979) have shown mortalities to juvenile migrants ranging from about 15 percent per dam for relatively high flow years to about 45 percent per dam for low flow years such as 1973 and 1977. Additional mortalities to adult migrants have ranged from an average of 4 or 5 percent per dam in low flow years to more than 10 percent in high flow years (Junge, 1976). With expanding powerhouse capacities in more recent years, overall survival rates of 85 percent per dam (15 percent mortality) have become unattainable even in ideal flow years. Although there can be some variation between dams, existing evidence indicates that average mortality for any single dam over a range of varying flow years currently approximates 20 - 25 percent.

In passing a sequence of dams, mortalities are not additive, but for 5 percent per dam accumulate as indicated in Table 3.

In order that losses be properly allocated to the various production areas, base runs are partitioned into various segments entering the Columbia

Table 2. Recommended Production Levels and Compensation Objectives

	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Coho	Summer Steelhead
Production Goals; Pre-McNary base run size	300,000	200,000	400,000	200,000	164,000	400,000
Current run levels 5-Yr. Ave. (1975-1979)	101,000	41,000	294,000	55,000	45,600	124,000
Continuing losses due to power development	199,000	159,000	106,000	145,000	118,400[1/]	276,000
Future - Lower Snake River compensation	74,800	48,800	33,800	0	0	105,300
Phase I compensation	54,300	44,900	56,500	68,400	50,000[2/]	66,700
Remaining losses due to passage mortalities	69,900	65,300	15,700	76,600	68,400	104,000

1/ Coho run reduction due mainly to change in hatchery management.

2/ Not based on 5% mortality.

Table 3. Cumulative Mortality and Average Assessment Per Dam When Passage Mortality is 5 Percent Per Dam

No. of Dams	1	2	3	4	5	6	7	8	9
Cum. Mortality (%)	5.0	9.8	14.3	18.6	22.6	26.5	30.3	22.7	27.0
Avg. Per Dam	5.0	4.9	4.8	4.6	4.5	4.4	4.3	4.2	4.1

or Snake rivers according to the particular group of dams which will intercept their migration (Figure 6). For example, fish producted in the Clearwater, Salmon, Grand Ronde, or Imnaha rivers constitute a segment (Area 8) that enters the Snake River between Lower Granite and Hells Canyon dams and which must pass four dams on the Snake and four dams on the lower Columbia River.

Total base runs have been allocated to the segmented production areas in Tables 4 - 8. Justification for this allocation is developed in the earlier report (Junge, 1980 unpub. m.s.).

Allocation of losses to the various segments of the base run may be illustrated in Table 4. Here, the 134,000 summer chinook produced in Area 8 must bass eight dams, four of which are Columbia River dams. With an average mortality of 4.2 percent per dam, the required compensation for the four Columbia River dams is 4 x 0.42 x 134,000 = 22,500 adults (Col. (5)).

Column (1) of Table 1 summarizes the results from Tables 4-8. The last three columns of Table 1 were computed in the same way as (1) using 15 percent mortality per dam as an example of eventual compensation requirement.

In accordance with Sections 4(h)(8) and (10)(A) of the Power Act, funding of the compensation portion of Phase I should be provided through the Bonneville Power Administration fund. The Administrator would allocate monetary costs to individual projects as appropriate, consistent with individual project impacts and system-wide objectives. Bonneville Power Administration expenditures shall be in addition to and not in lieu of other obligations and expenditures.

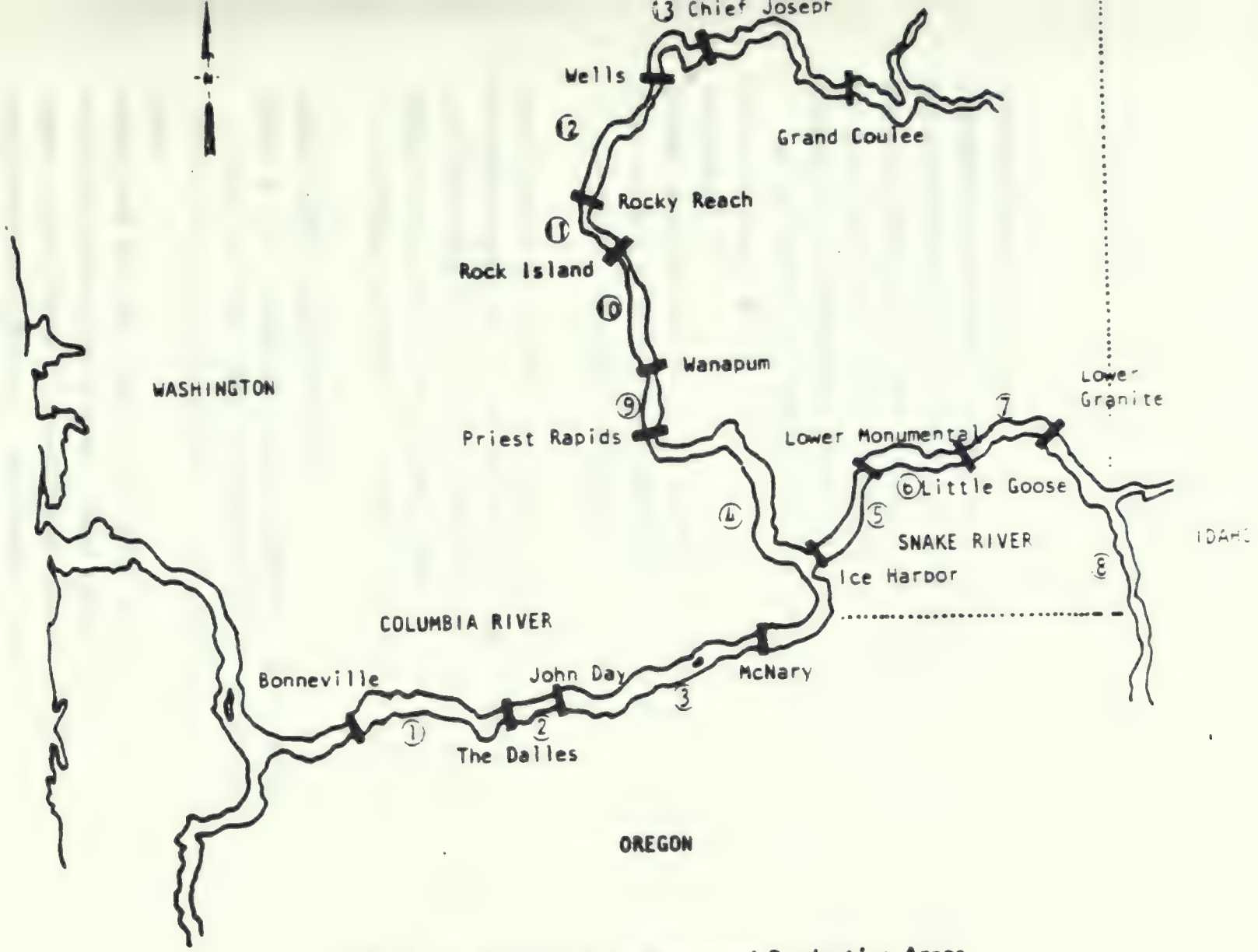

Figure 6. Definition of Segmented Production Areas.

Table 4. Definition of Base Run Size for Upriver Fall Chinook and Compensation Required for Passage Mortalities of 5 Percent (Phase I).

Definition of Area		Base Run Segment	Number of Dams Passed	Percentage Mortality Assigned Each Dam[1/]	Compensation Required for Columbia River Dams (adult returns)
Area	Dam Below Area				
		(1)	(2)	(3)	(4)
1	Bonneville	90,000	1	5.0	4,500
2	The Dalles				
3	John Day	90,000	3	4.8	13,000
4	McNary	120,000	4	4.6	22,100
5	Ice Harbor				
6	Lower Monumental	15,000	6[2/]	4.4	2,600[2/]
7	Little Goose				
8	Lower Granite	85,000	8	4.2	14,300
9	Priest Rapids				
10	Wanapum				
11	Rock Island				
12	Rocky Reach				
13	Wells				
Total		400,000			56,500

1/ This is based on an estimated mortality rate of 5 percent per day but is less than 5 percent when more than one dam is involved (see Table 3).

2/ Mortalities due to four Corps dams on Lower Snake River have already been addressed in Lower Snake River Compensation Plan. Consequently, for fish produced in tributaries above Ice Harbor Dam, passage compensation is required only for the four dams on the Lower Columbia River.

Table 5. Definition of Base Run Size for Upriver Summer Chinook and Compensation Required for Passage Mortalities of 5 Percent (Phase I).

Definition of Area		Base Run Segment	Number of Dams Passed	Percentage Mortality Assigned Each Dam[1/]	Compensation Required for Columbia River Dams (adult returns)
Area	Dam Below Area				
		(1)	(2)	(3)	(4)
1	Bonneville				
2	The Dalles				
3	John Day				
4	McNary				
5	Ice Harbor				
6	Lower Monumental				
7	Little Goose				
8	Lower Granite	134,000	8[2/]	4.2	22,500[2/]
9	Priest Rapids				
10	Wanapum				
11	Rock Island	26,400	7	4.3	7,900
12	Rocky Reach	3,300	8	4.2	1,200
13	Wells	36,300	9	4.1	13,400
Total		200,000			45,000

1/ This is based on an estimated mortality rate of 5 percent per day but is less than 5 percent when more than one dam is involved (see Table 3).

2/ Mortalities due to four Corps dams on Lower Snake River have already been addressed in Lower Snake River Compensation Plan. Consequently, for fish produced in tributaries above Ice Harbor Dam, passage compensation is required only for the four dams on the Lower Columbia River.

Table 6. Definition of Base Run Size for Upriver Spring Chinook and Compensation Required for Passage Mortalities of 5 Percent (Phase I).

Definition of Area		Base Run Segment	Number of Dams Passed	Percentage Mortality Assigned Each Dam[1/]	Compensation Required for Columbia River Dams (adult returns)
Area	Dam Below Area				
		(1)	(2)	(3)	(4)
1	Bonneville				
2	The Dalles	36,000	2	4.9	3,500
3	John Day				
4	McNary	21,000	4	4.6	3,900
5	Ice Harbor				
6	Lower Monumental				
7	Little Goose				
8	Lower Granite	206,000[3/]	8[2/]	4.2	34,600[2/]
9	Priest Rapids				
10	Wanapum				
11	Rock Island	17,800	7	4.3	5,400
12	Rocky Reach	5,500	8	4.2	1,800
13	Wells	13,700	9	4.1	5,000
Total		300,000			54,200

1/ This is based on an estimated mortality rate of 5 percent per day but is less than 5 percent when more than one dam is involved (see Table 3).

2/ Mortalities due to four Corps dams on Lower Snake River have already been addressed in Lower Snake Ri-er Compensation Plan. Consequently, for fish produced in tributaries above Ice Harbor Dam, passage compensation is required only for the four dams on the Lower Columbia River.

3/ Some of these are produced by Rapid River Hatchery as compensation for losses above Hells Canyon Dam.

Table 7. Definition of Base Run Size for Upriver Sockeye and Compensation Required for Passage Mortalities of 5 Percent (Phase I).

Definition of Area		Base Run Segment	Number of Dams Passed	Percentage Mortality Assigned Each Dam[1/]	Compensation Required for Columbia River Dams (adult returns)
Area	Dam Below Area				
		(1)	(2)	(3)	(4)
1	Bonneville				
2	The Dalles				
3	John Day				
4	McNary				
5	Ice Harbor				
6	Lower Monumental				
7	Little Goose				
8	Lower Granite				
9	Priest Rapids				
10	Wanapum				
11	Rock Island	80,000	7	4.3	24,100
12	Rocky Reach				
13	Wells	120,000	9	4.1	44.300
Total		200,000			68,400

1/ This is based on an estimated mortality rate of 5 percent per day but is less than 5 percent when more than one dam is involved (see Table 3).

Table 8. Definition of Base Run Size for Upriver Summer Steelhead and Compensation Required for Passage Mortalities of 5 Percent (Phase I).

Definition of Area		Base Run Segment	Number of Dams Passed	Percentage Mortality Assigned Each Dam[1/]	Compensation Required for Columbia River Dams (adult returns)
Area	Dam Below Area				
		(1)	(2)	(3)	(4)
1	Bonneville	12,200	1	5.0	610
2	The Dalles	32,000	2	4.9	3,140
3	John Day	24,000	3	4.8	3,460
4	McNary	15,000	4	4.6	2,760
5	Ice Harbor				
6	Lower Monumental	10,000	6[2/]	4.4	1,760[2/]
7	Little Goose				
8	Lower Granite	284,000[3/]	8	4.2	47,710
9	Priest Rapids	1,600	5	4.5	360
10	Wanapum	1,600	6	4.4	420
11	Rock Island	10,400	7	4.3	3,130
12	Rocky Reach	3,000	8	4.2	1,000
13	Wells	6,400	9	4.1	2,360
Total		400,200			66,710

1/ This is based on an estimated mortality rate of 5 percent per day but is less than 5 percent when more than one dam is involved (see Table 3).

2/ Mortalities due to four Corps dams on Lower Snake River have already been addressed in Lower Snake River Compensation Plan. Consequently, for fish produced in tributaries above Ice Harbor Dam, passage compensation is required only for the four dams on the Lower Columbia River.

3/ Some of these are hatchery produced as compensation for losses above Hells Canyon Dam.

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A P P E N D I X

to Special Report on the

LOWER SNAKE RIVER DAMS

Ice Harbor
Lower Monumental
Little Goose
Lower Granite

Prepared by Fish Commission of Oregon as supplement
to report of National Marine Fisheries Service and
Bureau of Sport Fisheries and Wildlife, September 1972

Portland, Oregon

March 1973

Appendix to Special Report on Lower Snake River Dams

INTRODUCTION

The report entitled "Special Report on the Lower Snake River Dams, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite" was submitted by the fisheries agencies to the Corps of Engineers in September 1972. The report concerns fish and wildlife compensation for the effects of these dams. It was prepared in response to Colonel Frank McElwee's April 11, 1966, letter to former Regional Director Paul T. Quick of the Bureau of Sport Fisheries and Wildlife.

We recognize that the report is difficult to follow for those not intimately connected with Columbia and Snake River fisheries problems. Consequently, we are supplementing the report with this appendix. In this appendix we shall demonstrate that use of the concept of "maximum" dam count to assess liability is justifiable. We shall show the levels of runs which should be maintained in the Columbia River system in order to counter the effects of dams constructed in recent years. This will be related to compensation being requested for the lower Snake River dams. We shall also give evidence of mortalities to adult salmonids resulting from the lower Snake projects which evidence was not available at the time the original report was prepared. We shall demonstrate that the dam counts which have seemingly held up favorably over the years are artifacts created by extensive curtailment of commercial fisheries to counter losses of adult fish passing dams. Finally, we shall demonstrate the serious impact of the main stem dams on our major fisheries.

ESTIMATE OF LOSSES DUE TO McNARY AND SUBSEQUENT DAMS IN COLUMBIA AND SNAKE RIVERS

In confining our attention to the more immediate effects of the four lower Snake River projects, we artificially fragment the broad picture and

tend to lose perspective. Dam construction occurring prior to the lower Snake projects has had a tremendous effect in depressing the Snake River runs. To base compensation at the four lower Snake River dams on these depressed levels is tantamount to ruining a man's business and then buying him out at a price far below its actual value. Most of this inequity and the resulting confusion in trying to measure it would not have occurred had it been possible to completely compensate for the effects of each dam at the time of completion. Prior to the current lower Snake River proposal, compensation for anadromous fish has been almost exclusively limited to restitution for runs completely blocked from spawning areas. Losses of adults and juveniles due to adverse passage conditions at and between dams have never been compensated for. That such losses do exist and are serious is well established by numerous studies by the fisheries agencies and the Corps.

In an effort to correct for these heretofore uncompensated losses in the entire Columbia River system, the fishery agencies early in 1971 requested an improved program to seek restitution. In a letter of February 22, 1971, General Roy S. Kelley (former Division Engineer of the North Pacific Division of the U. S. Army Corps of Engineers) suggested that a program for the mitigation of additional losses "should be initially formulated and recommended to us by the joint fishery agencies of the Northwest who possess expertise in these matters. We would then have a basis for documenting the severity of the problem, the justifiability of proposed measures, and should be in a sound position to make appropriate recommendations to higher authority in the Corps of Engineers and the Congress."

As a first step toward such a program, the Fish Commission of Oregon prepared what we include here as Appendix Tables 1 and 2. Appendix Table 1

demonstrates that following the completion of McNary Dam in 1953 and the ensuing construction of a series of major dams, adverse conditions severely reduced the productivity of the spawning escapement. To illustrate this, data on Columbia River salmon (spring chinook, summer chinook, and sockeye) and steelhead are tabulated for two periods:

(1) Pre-McNary-The Dalles brood years (1942-52) for which effects of Rock Island, Bonneville, and Grand Coulee dams were included.

(2) Post-McNary-The Dalles brood years (1957-67) which were additionally influenced to varying degrees by six dams on the Snake River and seven dams on the Columbia River (completed since 1957).

In Table 1, the measure of productivity for comparing the pre- and post-McNary periods is "return per spawner." To illustrate, if on the average one spawner produces one adult returning to the river 4 years later, the return per spawner is 1.0 and no harvest could be permitted if the run size were to be maintained. Moreover, if on the average each pair of spawners produces five adults returning to the river, the return per spawner would be 2.5, and three of each five fish or 60% of the run could be harvested and still maintain the run at the same level. We refer in the table to run size as a measure of "return" to the river and escapement as a measure of the "spawners."

The run size is the total number of adult fish returning to the Columbia River annually. It is estimated by adding the number of fish caught in the fisheries below Bonneville Dam to the Bonneville Dam count. Escapement is defined as the number of fish permitted to escape from the lower river fisheries, i.e., the numbers of fish passing over Bonneville Dam minus the commercial and Indian catches above Bonneville Dam. The term "escapement" used in this sense is meaningful since if upstream dams

Appendix Table 1. Basic Columbia River Salmon and Steelhead Data for Estimating the Production Rates (return per spawner) for the 11 Brood Years Preceding the Completion of McNary Dam and the 11 Brood Years After the Completion of The Dalles Dam

Period	Parameter	Salmon: Spring Chinook	Salmon: Summer Chinook	Salmon: Sockeye	Summer Steelhead
Pre- McNary-The Dalles brood years (1942-52)	Avg escapement (1942-52)	52,400	37,900	49,100	95,600
	Avg run size (Salmon: 1946-56) (Steelhead: 1947-57)	187,300	105,100	195,900	259,600
	Return per spawner	3.57	2.77	3.99	2.72
Post-McNary-The Dalles 1/ brood years (1957-67)	Avg escapement (1957-67)	83,200	82,500	72,500	130,000
	Avg run size (Salmon: 1961-71) (Steelhead: 1962-72)	172,500	94,500	100,400	200,800
	Return per spawner	2.07	1.15	1.38	1.54

1/ *It should be noted that the production in these years was also influenced in varying degrees by other dams: Brownlee (1958), Priest Rapids (1960), Oxbow (1961), Rocky Reach (1961), Ice Harbor (1962), Wanapum (1963), Wells (1967), Hells Canyon (1967), John Day (1968), Lower Monumental (1969), and Little Goose (1970).*

kill a portion of the escapement (or a portion of the juvenile migrants) the return per spawner will measure this reduction.

Although there is some variation in the age of returning adult salmon and steelhead, we have used a return age of 4 years for salmon and 5 years for steelhead based on scale analyses. Under this set up, we have assumed that the salmon escapements from 1942 to 1952 produced the salmon runs returning from 1946 to 1956. Similarly for steelhead we relate the runs returning from 1947 to 1957 to brood year escapement from 1942 to 1952. Ocean catches for runs considered here are generally minor and are therefore not included. Ocean catches of Columbia River steelhead and sockeye are insignificant, and scale studies of ocean caught chinook indicate that the vast majority of these are fall chinook.

As already stated, our measure of productivity is "return per spawner" which is merely the run size ("return") divided by the escapement ("spawner" The reduction in return-per-spawner values for recent years is rather dramatic for every species considered here. We might particularly draw attention to the "post" value for summer chinook of 1.15, recognizing that when the value drops below 1.0 the run is not even reproducing itself. Currently no direct fishery[1/] is permitted on this run although historically it was the single most important run in the Columbia.

To effectively regulate a fishery on anadromous species, it is important to determine the "optimum" or most desirable escapement needed to produce the greatest sustainable yield. By the late 1950's the accumulation of data from the fisheries and Bonneville counts supplied an excellent basis for estimating "optimum" escapement levels which were 80,000 each for spring

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1/ *A few summer chinook are taken incidentally to the harvest of sockeye salmon.*

chinook, summer chinook, and sockeye salmon and 120,000 for summer steelhead (line 2, Appendix Table 2).

The optimum run (line 1 of Appendix Table 2) is estimated by multiplying the optimum escapements by the return per spawner for the pre-McNary period. These are the run sizes that could have been maintained if optimum escapement levels had been followed and if the series of dams starting with McNary had not been constructed. Optimum productions are maintained by harvesting the difference between run produced and escapement required. We refer to this harvest as the "optimum sustainable yield."

To estimate what our fisheries are now losing under current production we must estimate what yields can currently be maintained. As a starting point we have assumed in Table 2 (current period) that the magnitude of the runs maintained by the 1957-67 broods (Table 1) can still be maintained. It is not proper, however, to use the escapement values for this period, because increased adult losses particularly since the completion of John Day in 1968 required increased adult escapements from the fisheries to get the same number of adults to the spawning areas. Consequently average escapements for the years 1968 to 1972 have been used to represent the escapements in the current period in Table 2. As we have seen in studying the optimum condition, the current sustainable yield is the difference between the current run size and the current escapement.

Finally the average yearly loss to the fisheries from dams completed since 1953 may be estimated by subtracting the current yield from the optimum yield. It is of interest to compare these losses with estimated losses presented in the lower Snake River report, keeping in mind that the majority of the spring and summer chinook and summer steelhead runs considered in Tables 1 and 2 are produced by Snake River tributaries. Estimated

Appendix Table 2. Computation of Average Yearly Loss to Columbia River Fisheries Based on Difference between Optimum Yield 1/ and Current Yield

Period	Parameter	Salmon			
		Spring Chinook	Summer Chinook	Sockeye	Summer Steelhead
Pre McNary-The Dalles	Average optimum run	285,600	221,600	319,200	326,400
	Optimum escapement	80,000	80,000	80,000	120,000
	Optimum sustainable yield (difference)	205,600	141,600	239,200	206,400
Current	Average run >(Table 1)	172,500	94,500	100,400	200,800
	Average escapement >1968-72	115,400	74,800	68,700	129,800
	Average sustainable yield (difference)	57,100	19,700	31,700	71,000
Average yearly loss to fisheries (difference between yields)		148,500	121,900	207,500	135,400

1/ *Optimum yield is average yearly harvest that could have been taken by fisheries if McNary and subsequent dams had not been constructed.*

Snake River losses are 58,700 for spring and summer chinook combined while Columbia River losses are 270,400 (see Table 2, 148,500 spring chinook and 121,900 summer chinook). Estimated losses for Snake River summer steelhead are 55,100 compared to Columbia River losses of 135,400. Sockeye runs to the Snake River are small and no replacements have been requested for this species.

It is of interest to note that the average optimum run sizes (i.e., the run sizes that could have been maintained had McNary and subsequent dams not been built) given in Table 2 are reasonably close to the maximum run sizes since 1946 of 281,000 spring chinook (in 1955), 207,000 summer chinook (in 1957), 335,000 sockeye (in 1947) and 383,000 summer steelhead (in 1952). This illustrates why maximum rather than average run sizes during this period are representative of river potential. Average runs during this period were not representative. This largely resulted from an overharvest of the runs combined with a drastic translocation program following completion of Grand Coulee Dam.

In the Special Report on the Lower Snake River Dams, maximum counts since the completion of McNary Dam are used as estimates of representative runs in the pre-McNary period. For the Columbia River system we have seen that maximum runs are representative of potential river production. Consequently the use of "maximum" run does not subject the Corps to the responsibility for maintaining runs which nature would permit only on rare occasions. Rather the compensation program requested here in conjunction with compensation being requested for other projects in the Columbia basin will, if obtained, merely help us to approach yields of salmon and steelhead that could have been maintained on a sustained yield basis in the late 1940's and early 1950's and could still be maintained if these projects had not been constructed.

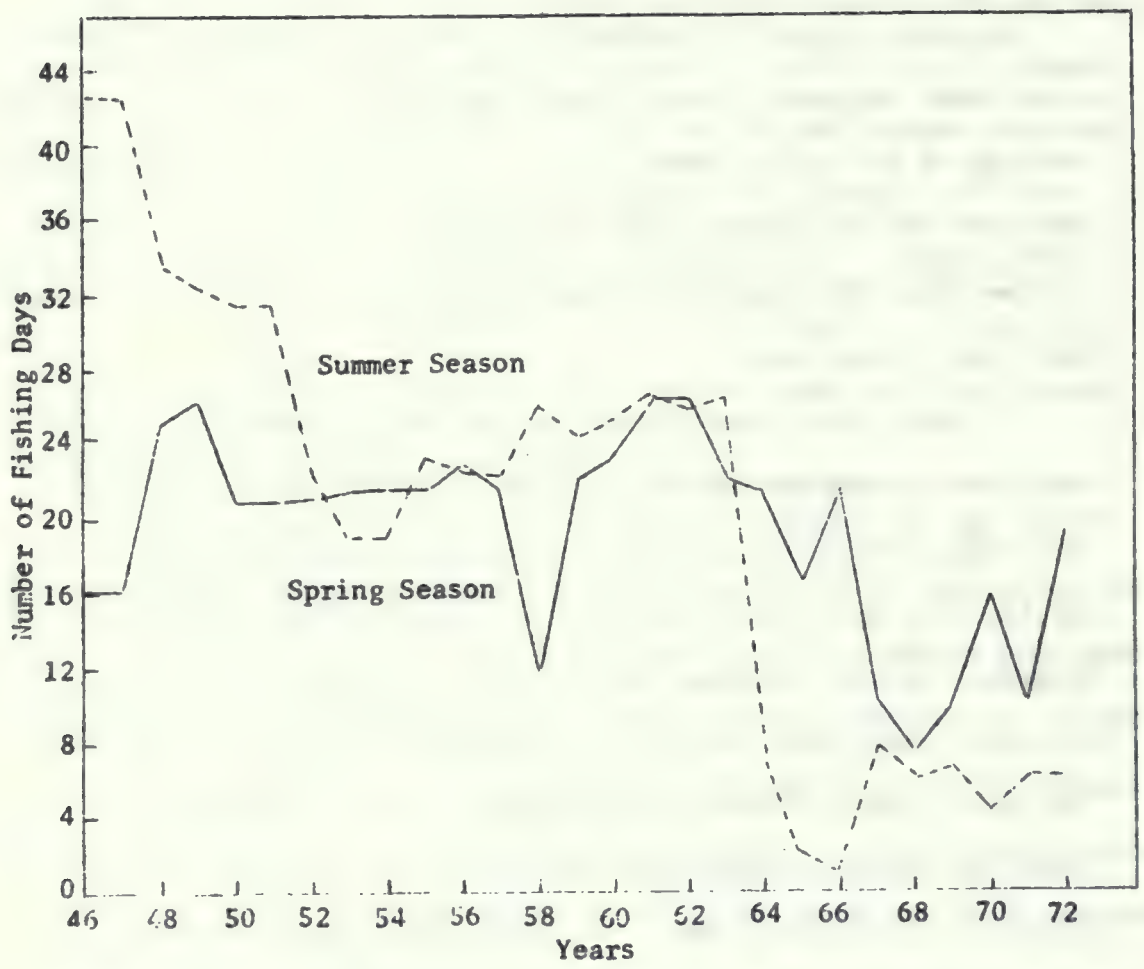
ACTUAL LOSSES TO FISHERY

The actual loss to the fishery in recent years is particularly distressing. In order to provide adequate escapement levels to spawning areas, increasing interdam losses of adult fish have been countered by severely curtailing the commercial fisheries. This has been accomplished both by reducing the number of fishing days allowed and by permitting fishing only during periods when fewer fish are present so that the resulting fishery is less efficient.

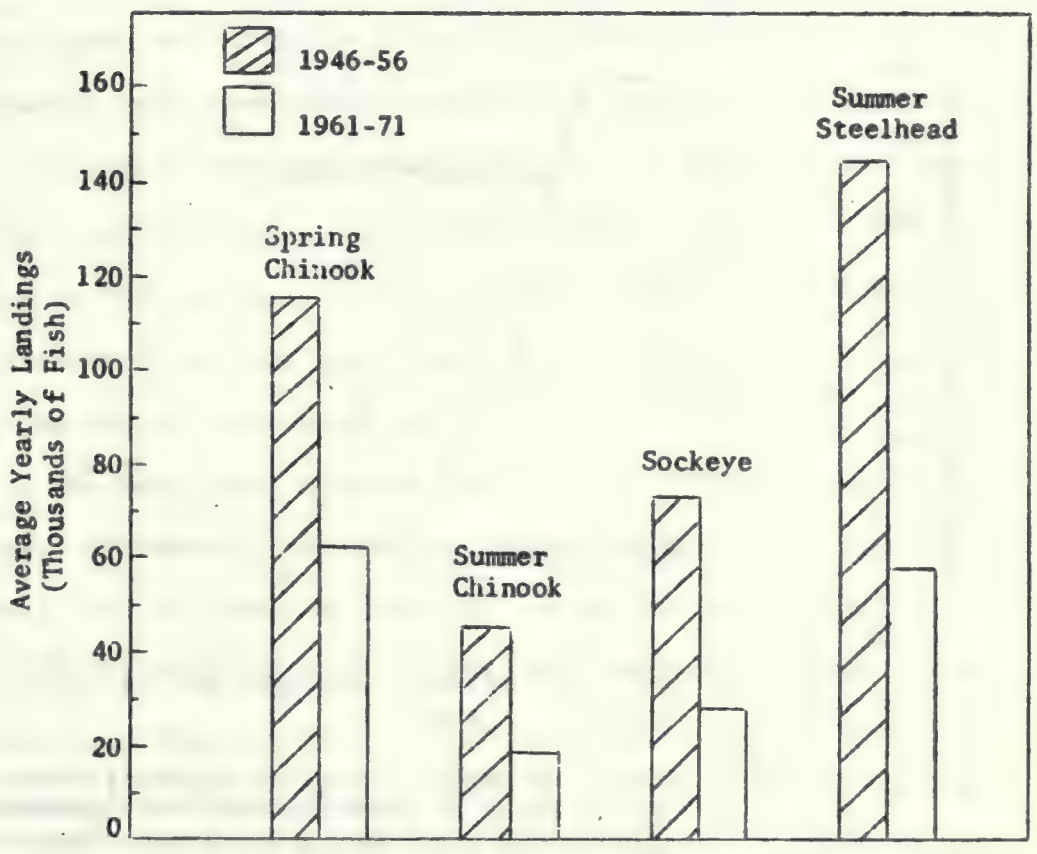
Appendix Figure 1 illustrates the decline in number of fishing days since 1946. Appendix Figure 2 shows the decline in the actual commercial landings of spring and summer chinook, sockeye, and summer steelhead for the same pre- and post-McNary years considered in Appendix Tables 1 and 2. It is clear that the landings of these species have been reduced to less than half their former levels.

In addition to compensating for increasing losses of fish between dams additional escapement has been allowed to compensate for prespawning mortalities occurring to fish after they have passed the uppermost dam. We believe that many of these mortalities resulted from nitrogen gas bubble disease. However, prespawning mortality was observed during 1972 when nitrogen levels were relatively low because of river flow regulation by the Corps. Observations of fish on and below their spawning grounds indicated that delayed mortalities resulted from a high incidence of physical injury to fish passing dams. This prespawning mortality is illustrated by the declining number of spawning nests (redds) per 100 fish counted over the uppermost dam (Appendix Figure 3). 1/

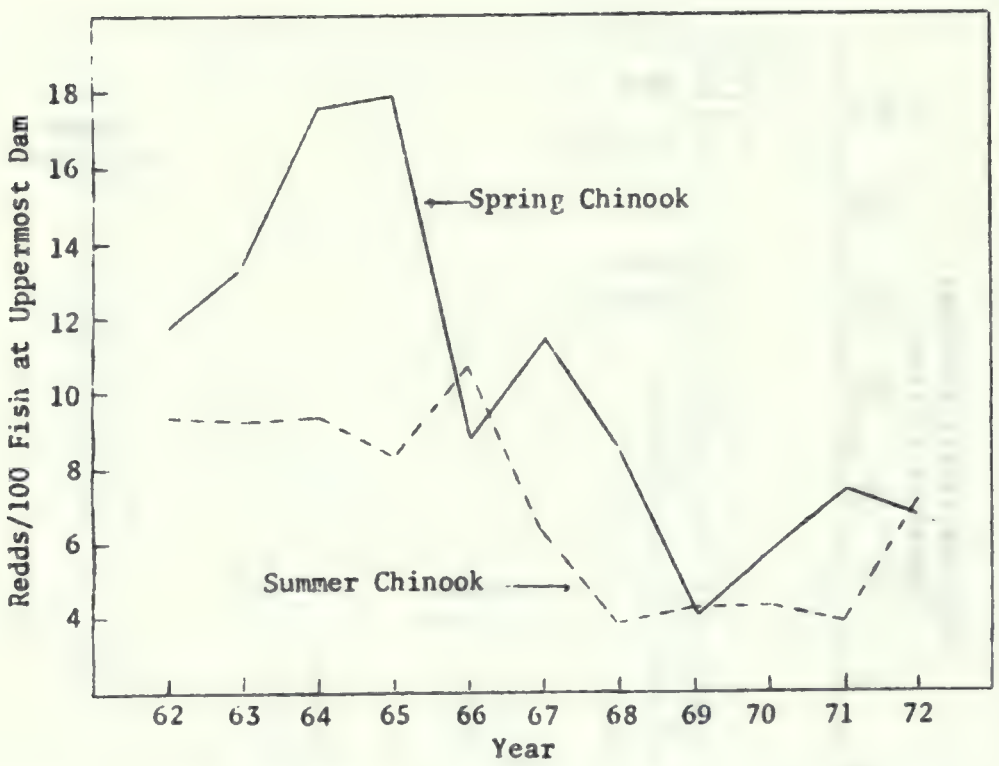
1/ *Redd counts supplied by Idaho Department of Fish and Game.*



Appendix Figure 1. Columbia River Commercial Fishing Seasons for Salmon Below Bonneville Dam, 1946-72



Appendix Figure 2. A Comparison of Average Annual Commercial Landings in Zones 1-6 for the Years 1946-56 and 1961-71 of Spring Chinook, Summer Chinook, Sockeye, and Summer Steelhead



Appendix Figure 3. Number of Redds in Standard Spawning Ground Survey Units in Idaho per 100 Fish Counted Over Uppermost Dam for Spring and Summer Chinook, 1962-72 1/

1/ *Redd count data supplied by Idaho Department of Fish and Game.*

IMPLICATION OF COLUMBIA RIVER LOSSES TO LOWER SNAKE RIVER PROGRAM

What should be most clear from the foregoing material is the magnitude of the fish losses in the Columbia River due to dams constructed in the last 20 years, and the inordinate hardship on the resource and the fisheries if reasonable compensatory procedures are delayed further. Losses due to Snake River projects have been expanding since the completion of Ice Harbor Dam in 1962, and serious losses related to main-stem Columbia River dams jumped sharply in the late 1950's and have continued year after year since that time. It could be argued that some of these losses result from environmental changes in tributary streams. However, during the period studied here, extensive screening of water diversions, other stream improvements, and increased hatchery production of spring chinook and steelhead have countered most of the adverse effects occurring in these tributaries during this period. It should be made clear that the hatchery production referred to is in no way connected with compensation for fishery losses at main-stem Corps projects.

We have given evidence that it is valid to consider maximum runs as rough estimates of optimum production. We have also shown that the numbers of spring and summer chinook and summer steelhead requested to compensate for Snake River projects is small when compared to total Columbia River losses and have pointed out that Snake River tributaries are the major producers of these stocks.

Modifications of lower Snake River projects to reduce mortalities (particularly to juvenile migrants) are currently underway. These include the installation of slotted bulkheads in existing skeleton units, the installation of deflectors in spillway units, and the development of

travelling screens to divert juveniles from entering the turbines. For the most part, these modifications are related to the serious nitrogen problem which has been developing in recent years. These modifications have not been considered in the lower Snake River report for a number of reasons. In the first place, no compensation has been requested for nitrogen losses although fisheries agencies as well as pollution control agencies in the Northwest have requested that the above measures be taken to reduce levels of nitrogen supersaturation. Secondly, the measures taken to reduce nitrogen levels introduce other sources of mortality. Direct mortalities to juvenile salmon passing through bulkheads are so great that at present the bulkheads are not used when large numbers of downstream migrants are in the river. Spillway deflectors are a possible source of mortality to both juvenile and adult salmonids. Travelling screens which may divert more than 80% of migrants approaching turbine units also induce mortalities. Furthermore, in the lower Snake River report no compensation has been requested for mortalities to adult salmon although serious delayed mortalities have been demonstrated, and serious mortalities to adults have been established directly at lower Columbia River dams as well as at Ice Harbor Dam, one of the Snake River projects under consideration. Consequently the losses we have not considered should more than counter any improvements from project modifications.

The process of obtaining reasonable compensation for both Snake and Columbia River projects will take quite a few years even if plans for hatchery construction are initiated immediately. Periodic evaluations can adjust for any benefits from project modifications as well as any additional losses due to peaking and other operational procedures. Further delay of the compensatory process, however, could have a serious impact on the viability

of our fish runs and our fisheries. Because of the Columbia and Snake River dams, fishermen have already lost an accumulation of tens of millions of pounds of prime salmon and steelhead. The present compensation program is not addressed to these past losses but rather is aimed at reducing such losses in the future.

In conclusion we would urge that plans for major hatchery construction not be delayed. If all of the hatcheries requested as well as project modifications presently considered are realized, the lower Snake River projects will not be over compensated. Considering the additional losses due to lower Columbia River projects it is clear that it is the resource and fisheries that are on the short side of the ledger.

Fish Commission of Oregon

March 7, 1973

CHAPTER 1

OBJECTIVE I:

Juvenile Migrant Survival

CHAPTER I
OBJECTIVE I: JUVENILE MIGRANT SURVIVAL

Salmon and steelhead are anadromous fish. They hatch and live their early lives in freshwater streams and rivers, migrate to the ocean where they grow to maturity, and return to their natal stream as adults to spawn.

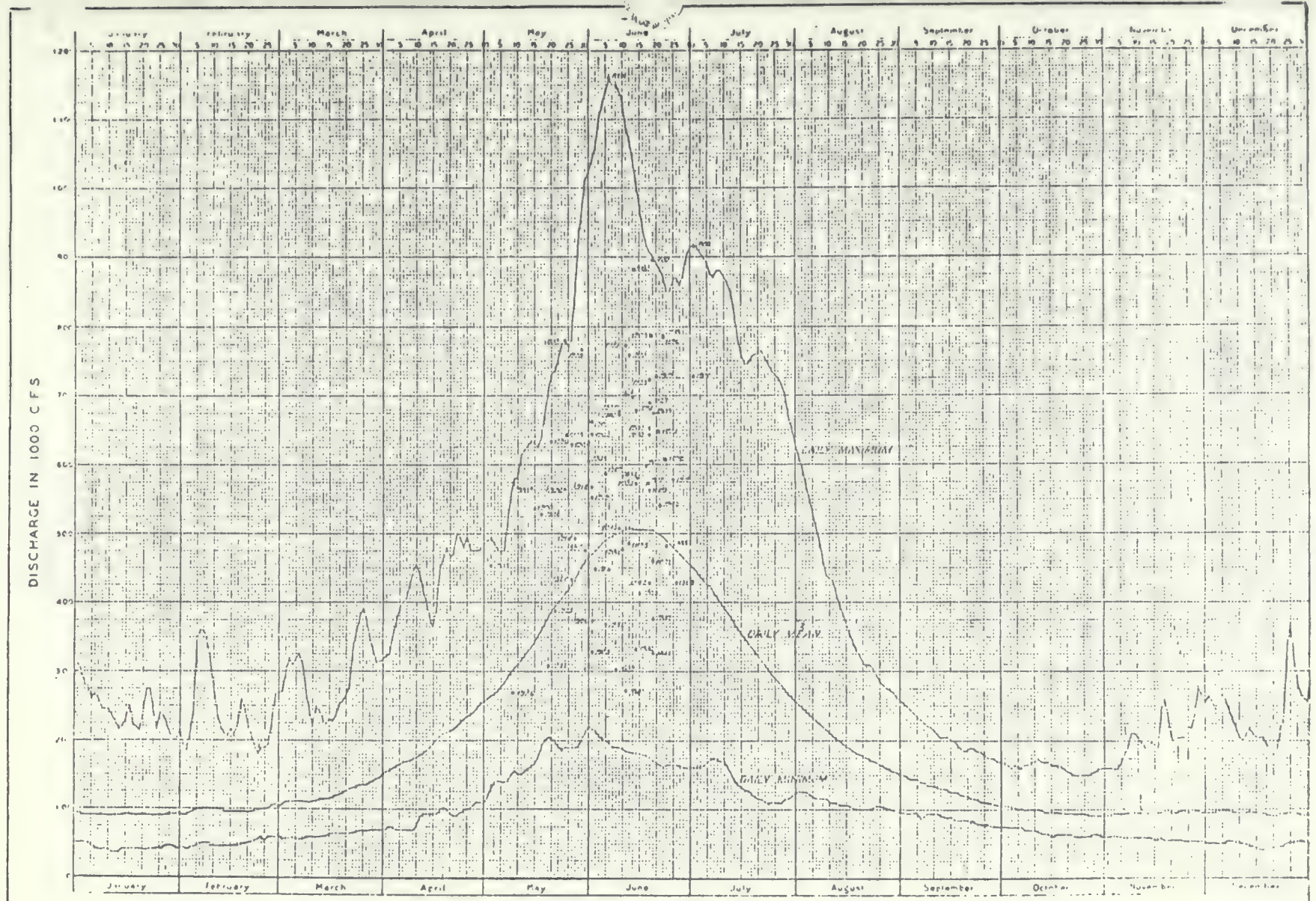
Significant physiological changes occur in the young fish, or parr, which make it possible for them to survive the change from fresh to saltwater. At the same time, they develop an urge to migrate. Noticeable physical changes in coloration markings occur. The migrating fish, called smolts, travel down the streams and rivers to the ocean.

When the Snake and Columbia rivers were in their natural state, they were free-flowing rivers which followed the natural cycle of the melting snowpack (Figure 1). It is estimated that it took migrating smolts 22 days to travel from the Salmon River to the lower Columbia area (Schweibert,). The fish received a significant assist from the spring freshets which occurred about the time of their seaward migration. Free-flowing waters did not reach higher temperatures which were undesirable for migrating fish.

During the spring runoff, turbidity was generally high, a factor which may be beneficial to migrants by providing concealment from predators (McCrimon, 1954). Chinook salmon fry have been found to increase migration with increase in turbidity (Thomas, 1975).

In the 1930's, Rock Island and Bonneville dams were constructed on the mainstem of the Columbia, representing the beginning of major changes in the Snake-Columbia River system. Over the years, more dams have been constructed and with the exception of relatively short stretches, the rivers have been converted to a series of manmade reservoirs which present a greatly altered environment for migrating fingerlings.

Impoundments created by construction of dams have reduced the peak flow and the flushing action which it created, and also caused a shift in the



MAXIMUM ANNUAL MEAN DAILY Q COLUMBIA RIVER, THE DALLS, OREGON

YEAR	DAY	C F S	YEAR	DAY	C F S	YEAR	DAY	C F S	YEAR	DAY	C F S	YEAR	DAY	C F S
1876	3 JUNE	443,000	1893	14 JUNE	651,000	1908	19 JUNE	651,000	1923	10 MAY	581,000	1938	31 MAY	404,000
1877	18 JUNE	681,000	1894	6 JUNE	1,160,000	1909	19 JUNE	675,000	1924	26 MAY	611,000	1939	21 MAY	391,000
1878	1 JULY	914,000	1895	31 MAY	875,000	1910	14 MAY	366,000	1925	31 MAY	682,000	1940	5 JUNE	384,000
1879	17 JUNE	943,000	1896	22 JUNE	835,000	1911	12 JUNE	534,000	1926	8 MAY	369,000	1941	11 JUNE	522,000
1880	11 JUNE	843,000	1897	30 MAY	780,000	1912	1 JUNE	369,000	1927	18 JUNE	630,000	1942	10 JUNE	529,000
1881	13 JUNE	523,000	1898	30 JUNE	659,000	1913	12 JUNE	759,000	1928	29 MAY	455,000	1943	21 JUNE	394,000
1882	11 JUNE	639,000	1899	30 JUNE	710,000	1914	27 MAY	493,000	1929	19 JUNE	660,000	1944	10 JUNE	376,000
1883	21 JUNE	482,000	1900	13 MAY	536,000	1915	1 JUNE	528,000	1930	14 JUNE	581,000	1945	4 JUNE	507,000
1884	9 JUNE	675,000	1901	1 JUNE	672,000	1916	1 JULY	727,000	1931	19 MAY	458,000	1946	10 JUNE	481,000
1885	23 JUNE	496,000	1902	1 JUNE	644,000	1917	20 JUNE	707,000	1932	28 MAY	365,000	1947		
1886	15 JUNE	564,000	1903	19 MAY	747,000	1918	25 JUNE	539,000	1933	18 JUNE	530,000	1948		
1887	3 JUNE	361,000	1904	26 MAY	622,000	1919	1 JUNE	553,000	1934	2 MAY	353,000	1949		

WAR DEPARTMENT
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER
PORTLAND, OREGON

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McNARY DAM PROJECT
COLUMBIA RIVER, WASHINGTON-OREGON

SUMMARY HYDROGRAPHS

Recommended
Approved

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timing of the peak flow (Figure 2). Water velocities in the reservoirs are slower than the free-flowing river, and the migration of fingerling chinook salmon and steelhead takes nearly three times as long as through the free-flowing river (Raymond, 1979). Delays of migrants, if of sufficient duration, can cause them to lose their migrating urge, revert to the parr stage, and not complete their normal migration and return as adults.

Slower flows result in greater heat absorption by the water with consequent increases in water temprature. Increase in water temperature can significantly alter the year's composition of algae, plankton, invertebrates, and fish which are resident in the system, the concentrations of dissolved gases in the water, the resistance of migrants to disease, and their general well-being. River temperatures often exceed 13°C, an apparently critical temperature (Zaugg, 1972) well before the migration is over and the fish may be unable to adjust to their environment.

Warmer water is favored by many predators of migrating salmon, and the slower water velocities give predators a better opportunity for capture.

As water temperature increases, its ability to retain dissolved gases decreases and a condition of supersaturation may occur. The same is true of body fluid in the fish. Although short-term exposure to conditions of gas supersaturation may be tolerated, serious harm or death may result when migrants are exposed to such conditions for the extended periods now required to complete their migration (Ebel, et al., 1975).

The dams themselves present hazards to migrants which must pass through the turbines or over spillways. High velocity shear planes, mechanical obstructions and impaired clearances, sudden pressure changes, and cavitation all can produce injuries or death. Direct losses of fish passing through turbines were measured at McNary Dam at 11 percent and direct spillway losses at 2 percent (Schoeneman, et al., 1961). When indirect turbine mortality is included, however, the losses are much higher, up to 30 percent (Long, et al., 1968, 1975).

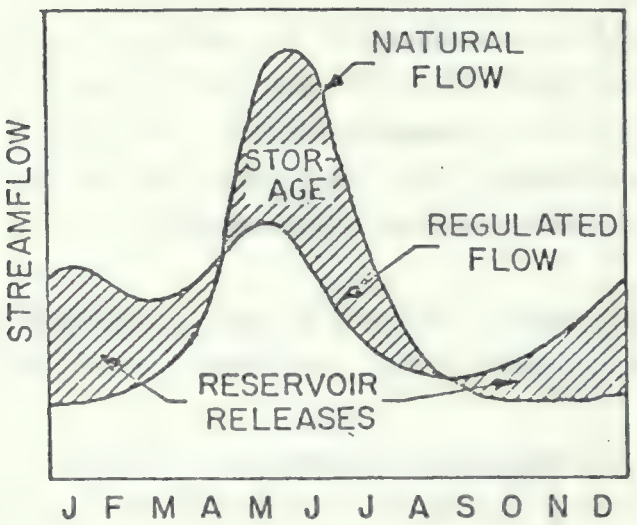

Figure 2.

Effect of Reservoir
Regulation on Flows at
The Dalles

Losses at a single dam might not prevent the maintenance of viable runs, but fish migrating from the upper reaches of the river system pass through as many as 8 or 9 dams. The serial attrition caused by multiple dam passage may, during low-flow years, destroy 95 - 98 percent of the entire migrant population (Sims, et al., 1978).

The overall effects of dams on migrating salmonid smolts are composed of many complex interrelationships, few of which are completely understood. Some are system-wide considerations, others relate to only one or a few specific installations. Much study is still needed to determine means whereby losses of migrating salmonid fingerlings may be reduced. A number of specific problems are described in the following Subobjectives.

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Subobjective 1.1: Provide minimum flow regimes in the Columbia and Snake Rivers throughout the juvenile downstream migration period.

Introduction: Construction of hydroelectric projects on the mainstem Snake and Columbia Rivers has greatly altered flow conditions. Prior to dam construction downstream migrant salmon and steelhead were dependent on the natural flow regime.

The construction of Grand Coulee Dam in the early 1940's created the first major change in flow conditions in the Columbia River. Additional large upstream storage projects and numberous mainstem run of the river projects have been constructed since then. Taken as a whole, these projects provide nearly complete year-round control of Columbia River flows. Changes in flow patterns have occurred in three ways, hourly, daily and seasonally.

The alteration in the natural hydograph has in turn altered downstream migration of salmon and steelhead. Water management for power production and reservoir storage has created impoundments with lower flows and velocities. Reduced river flow and velocities during the time of normal downstream migration of juvenile salmon and steelhead causes delay, increased mortality and residualism. The combined effect of these river changes and flow patterns can be catastrophic to upriver fish runs. The low flow conditions occurring in 1973 and 1977 are dramatic examples of these problems. Record high juvenile mortality occured both years and the adult returns of spring chinook salmon and steelhead from the surviving juvenile migrants were extremely depressed in both 1975 (Raymond 1979) and 1979.

Viability of upriver runs of anadromous fish is dependent upon the provision of instream flows for improved juvenile passage and survival.

The daily and hourly flow pattern changes from power peaking operation and their impact on anadromous fish runs were recognized. Greenland (1969) prepared a report forecasting the impacts of future peaking operations on anadromous fisheries. In 1972, Wagner (1972) analyzed requirements for fish passage at dams and through various reaches of the rivers and reservoirs.

This analysis was based largely on historical river conditions prior to 1958, fish count records, results of fish research programs and actual limitations on the operation of fish passage facilities. Wagner presented recommendations concerning minimum flows, maximum flows, daily and hourly rates of change in flow and tailwater and forebay levels required to operate the fish passage facilities.

By the mid-1970's, anadromous fish runs in the upper Columbia and Snake River systems had declined to the point where highly valuable fisheries were being curtailed or eliminated (Collins et al. 1975). To recover from these impacts, the fishery agencies (through the Columbia Basin Fishery Technical Committee) developed provisional instream flow recommendations. These provisional recommendations included the lower Snake, mid-Columbia, and lower Columbia Rivers, and were concerned with minimum daily average flow as well as minimum instantaneous flow. These provisional recommendations were based on the best information available at the time. Meanwhile, a comprehensive research program funded mainly by the Corps of Engineers and NMFS had begun adding significantly to information concerning the instream flow needs of Columbia River anadromous fish (Raymond 1968; Raymond et al. 1974; Raymond et al. 1975; Raymond 1979; Raymond and Sims 1980; Sims et al. 1976, 1977, 1978; Sims and Ossiander 1981). These studies are scheduled to continue into 1986.

Current Status: Minimum flows are the major variable governing flow related losses. Flows are related to delay of juveniles migrating to the ocean and this delay is related to mortality. Physiological and biological factors also relate delay to mortality.

Juvenile salmon and steelhead migrating to the ocean must adhere to a critical time schedule. If delay disrupts this schedule, serious mortality will occur. This is primarily due to the effect of delay on the smoltification process. Smoltification is a physiological state which exists in juvenile salmon and steelhead for a limited period of time. During this period juvenile (smolts) are motivated to migrate downstream and are physiologically capable of adjusting from a freshwater environment to a saltwater environment. Adams et al. (1975) showed that for some races of steelhead, nonmigratory

juveniles (parr) undergo a transformation to smolts when reared in water temperatures below 53 F. In addition, Zaugg et al. (1972) showed that in some races, smolts will revert to parr if exposed for significant periods to water temperatures above 54 F.

Temperatures above 54 F are regularly reached in the Columbia River by mid-May. Since significant migration of smolts usually begins in the Snake River in mid-April, they have only about 30 days to move through the main stem rivers if the impact of reversion level temperatures is to be minimized. Even in a moderate flow year, smolt travel time through eight dams and reservoirs can take approximately 41 days, which clearly shows the limited time frame available to these fish and the critical need for adequate flows to move them quickly through the river during this period. Zaugg et al. (1972) have also shown that regardless of temperature some races of steelhead will revert to parr by late June if the remain in fresh water. Adams et al. (1975) further demonstrate that, in the adjustment from fresh water to salt water, survival drops from almost 100% for steelhead smolts to about 20% for juvenile steelhead that have reverted to the parr stage. The NMFS[2/] has shown similar reductions in the survival of salmon that have reverted to parr.

Because of the complexity of river conditions and survival variables, the relationship between juvenile mortalities and river flow is difficult to study and impossible to quantify precisely. Nevertheless, available data indicates that minimum flows are essential if even modest harvestable fish runs are to be maintained.

2/ Personal communication, Conrad Mahnken, NMFS, Manchester, Washington

With respect to historical and free flowing river conditions, studies (Collens et al. 1975) have shown that the rate of migration through a free flowing section of the Snake River under low flow conditions is about the same as the rate of migration through the Columbia and Snake River reservoirs under high flow conditions. The studies also indicate that mortalities are less in the free flowing river section than through the reservoirs in high flow years.

Since 1966, studies conducted by the Corps of Engineers and National Marine Fisheries Service have monitored smolt survival from the upper Snake River dams to The Dalles Dam on the lower Columbia River (Raymond, 1968; Collins et al. 1975; Sims and Ossiander 1981).[3/] These studies have provided significant information concerning flow and its effect on smolt delay and survival.

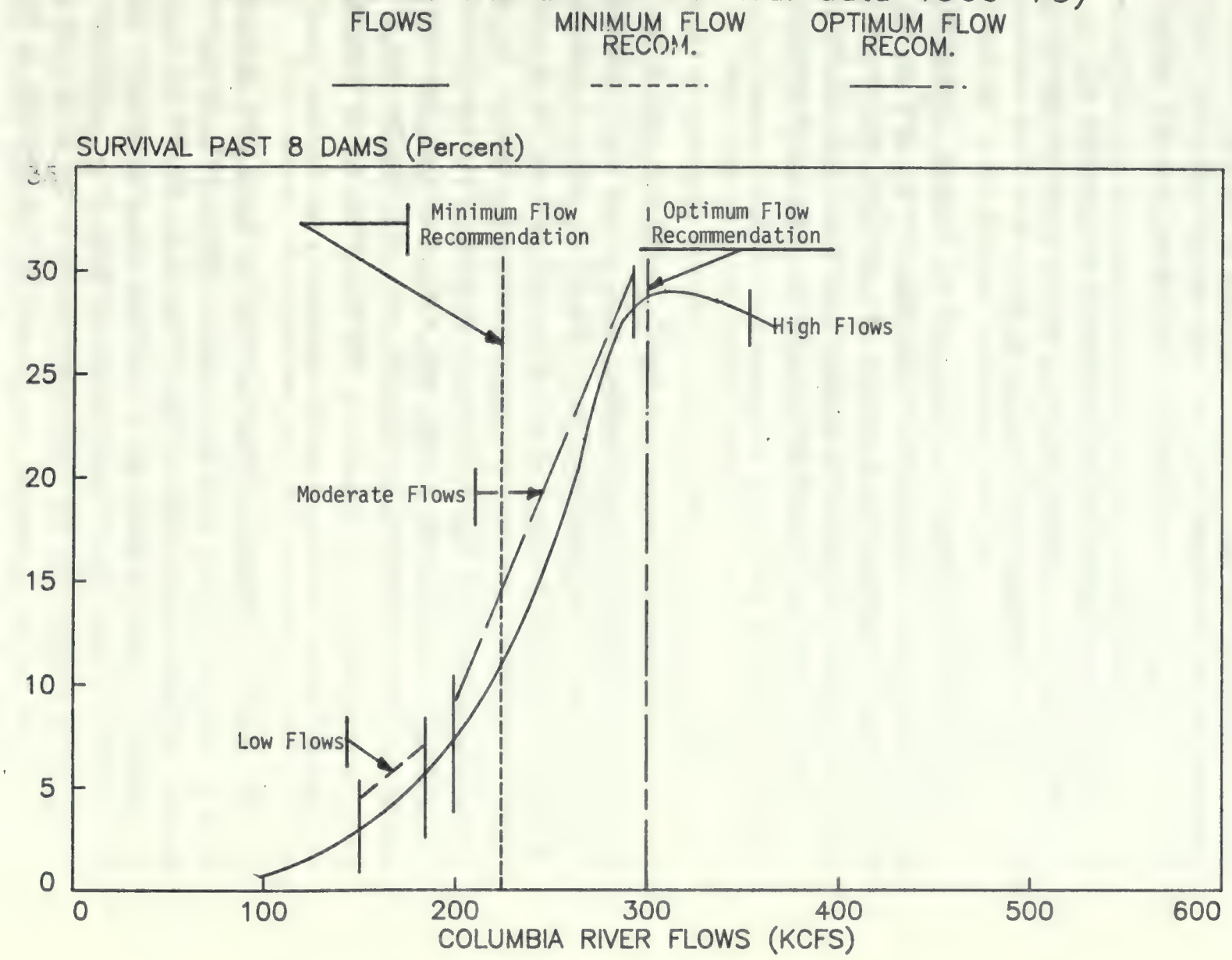
For purposes of these studies, flows were classified as "low", "moderate", or "high", as follows:

	Low flows (Kcfs)	Moderate flows (Kcfs)	High flows (Kcfs)
Snake River	30-50	80-100	120-180
Lower Columbia River	150-180	200-300	350-500

Travel time in passing a chain of eight dams on the Snake and Columbia Rivers was used as a measure of delay. Travel time varied from 23 days in high flow years to 69 days in low flow years. Fish survival associated with these migration rates varied from 25-30% for high flow years to 7-25% for moderate flow years to 3-5% for flow years. (Exhibit 1)

3/ Collins et al, 1975 and Sims and Ossiander 1981 summarizes this work, but many pertinent details are given in Annual Progress Reports prepared by NMFS from 1966 .

EXHIBIT 1.--Flow survival relationship. (Flow measured at The Dalles--survival data 1966-75)



Adopted from Collins, et al, 1975

Similarly, Sims and Ossiander (1981) have quantified the relationship of rates of downstream movement of smolts and flows in the Snake River (Attachment 1, Figure 1 and Table 1). Their results indicate that not only does flow influence smolt travel time, but that low flows have a greater influence than high flows. For example, travel time was substantially reduced for chinook salmon from thirty days at 50,000 cfs to seventeen days at 100,000 cfs; whereas increasing flows from 100,000 cfs to 175,000 cfs reduced travel time from seventeen days to eleven days.

Sims and Ossiander (1981) also developed flow/survival regressions for smolts migrating down the Snake River (Attachment 1, Figure 2 and Table 2). Based on these regressions, survival rates of Snake River smolts to The Dalles Dam in excess of 16% can be expected only when river flows at Ice Harbor Dam during peak periods of migration are in excess of 100,000 cfs. Flows of less than 75,000 cfs can be expected to produce survival rates of from 2 to 5%.

The flow/survival and flow/travel time regressions prepared by Sims and Ossiander clearly show a strong correlation between flow volume and survival and travel time. The confidence intervals of these regression equations are too broad to precisely determine how small increments of flow changes will change survival and travel time of chinook and steelhead smolts. However, it is clear that reduction of flow in the Snake River below 100,000 cfs substantially reduces survival of Snake River stocks of salmonids. Other data on flow survival relationships presented in exhibit 1 clearly shows that flows less than 300,000 cfs (measured at The Dalles Dam on the Columbia) substantially reduces survival of smolts migrating in the Columbia River.

Fish delayed by insufficient flows may take up residence in reservoirs, either as "residuals" which never go to sea or "holdovers" which may complete migration after an extended stay in the reservoirs. "Residuals" do not contribute to adult fisheries and do not successfully reproduce. Studies of spring chinook fish scales, which record the duration of freshwater residence, have shown that few "holdovers" survive to return as adult fish. In 1977, under low flow conditions, about 50% of the juvenile chinook salmon and steelhead from the Snake River tributaries never passed Lower Granite

Dam (the uppermost dam on the lower Snake River). Purse seining operations of NMFS indicated that massive numbers of these fish were present in the Lower Granite pool, and very few fish delayed beyond the normal passage time ever passed Lower Granite Dam.

The minimum flow recommendations in this document reflect the correlation between river flows and fish survival. Referring to Exhibit 1, maximum survival of smolts in the Columbia River would be achieved at flows of 300,000 to 350,000 cfs. Increasing flows above this level would not significantly increase survival. Survival increases dramatically, from 3% to 30%, as flows increase from 150,000 cfs to 300,000. Thus, if optimal biological considerations are used, the minimum flow recommended at The Dalles would be 300,000 cfs, the point at which the survival curve begins to decline, with corresponding optimal flows in the Mid Columbia and Snake Rivers.

Under current power system operations, flows of 300,000 cfs or more would be extremely difficult to achieve without significant reduction of hydroelectric generation. Based on these power considerations, the optimal biological flows are not being recommended for the short term but rather the minimum flow level of 220,000 cfs at The Dalles with corresponding minimum flows in the Mid Columbia and Snake Rivers; this flow level falls at the low end of the range of moderate flows, and would still result in mortality of approximately 90%. Flow levels lower than 220,000 cfs have not been considered acceptable, since they would result in fish mortalities greater than 90% and survival lower than 10%, with corresponding impacts on commercial, recreational and tribal fisheries.

It is important to stress that the flows recommended in this document are minimum flows based on current biological knowledge, current power system constraints, and current stoage capacity and allocation. Higher flow levels, up to the 300,000 cfs or greater optimal flow, may be required based on new fish survival data, new flexibility in the power system, or changes in water availability. The objective for future development of the Columbia River Power System should be operations that allow the minimum spring flows to be met or exceeded in all years.

Finally as indicated in Chapter G Indian treaty obligations are not subject to a fish-power balancing procedure. For this reason, the Columbia River Inter-tribal Fish Commission does not endorse the 220,000 minimum flow but recommends optimal flows of 300,000 cfs or greater on the mainstem of the Columbia River and corresponding optional flows in the Mid Columbia and Snake Rivers.

Attachment 1.
Figure 1.--Regression line for flow at Ice Harbor Dam[1/] and travel time from the upper Snake River dam to The Dalles Dam for Snake River yearling chinook salmon and steelhead smolts, 1973-1979.

1/ At migration peak ± 7 days.

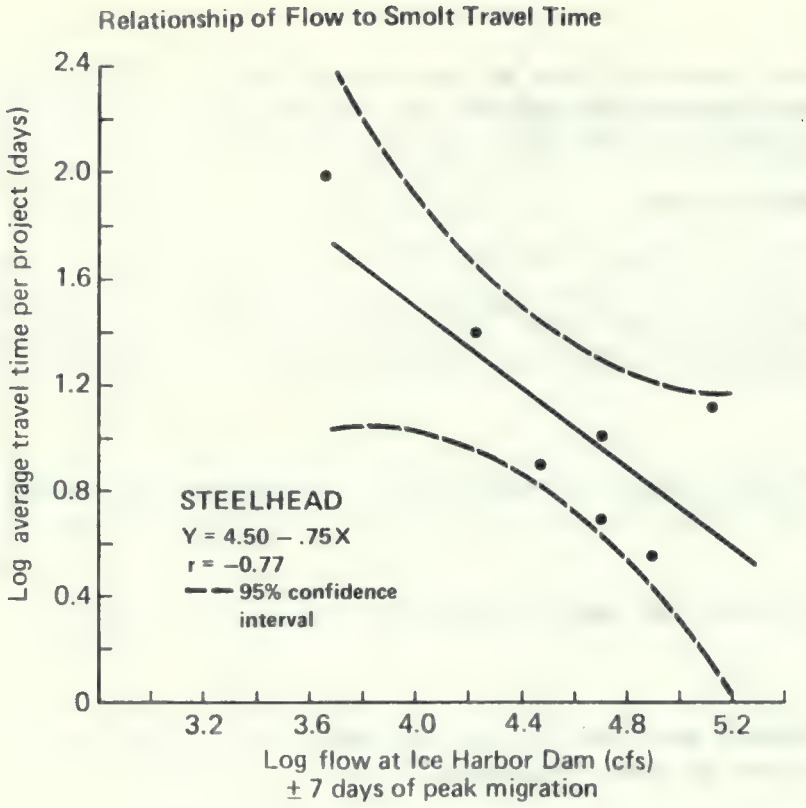
Attachment 1.
Figure 2.--Regression line for river flow at Ice Harbor Dam and survival of Snake River yearling chinook salmon and steelhead smolts, 1973-1979.

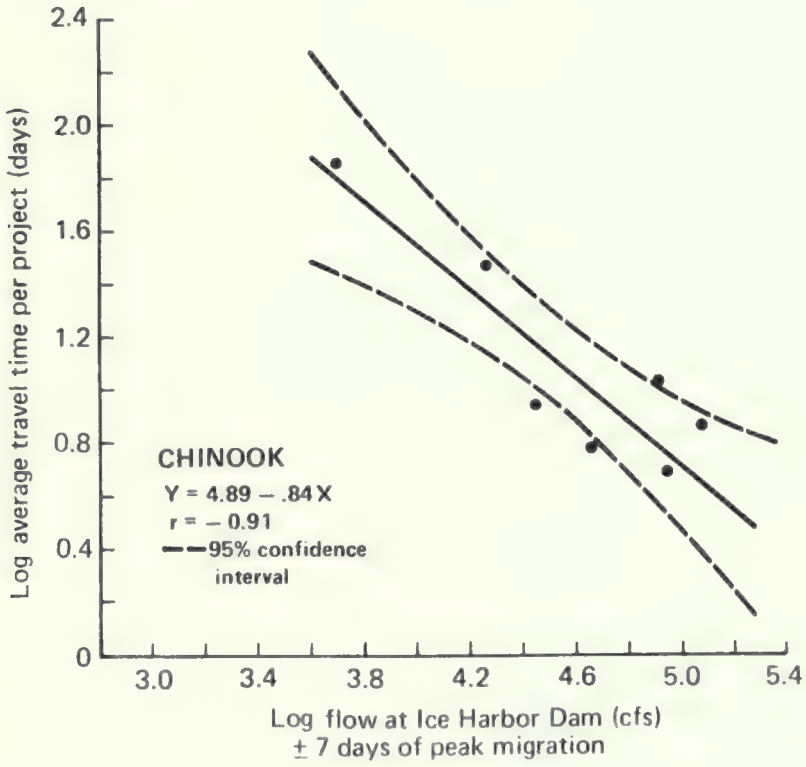
Attachment 1.
Table 1.--Predicted travel time for yearling chinook salmon and steelhead smolts from Lower Granite Dam to The Dalles Dam, given various flow levels.[a/]

a/ Avg. flow at Ice Harbor Dam during migration peak (± 7 days).

Attachment 1.
Table 2.--Predicted smolt survival at various levels of flow at Ice Harbor Dam at the time of peak migration.[a/]

a/ Average flow during the period ± 7 days from migration peak.





Attachment 1

Figure 1.--Regression line for flow at Ice Harbor Dam[1/] and travel time from the upper Snake River dam to The Dalles Dam for Snake River yearling chinook salmon and steelhead smolts, 1973-1979.

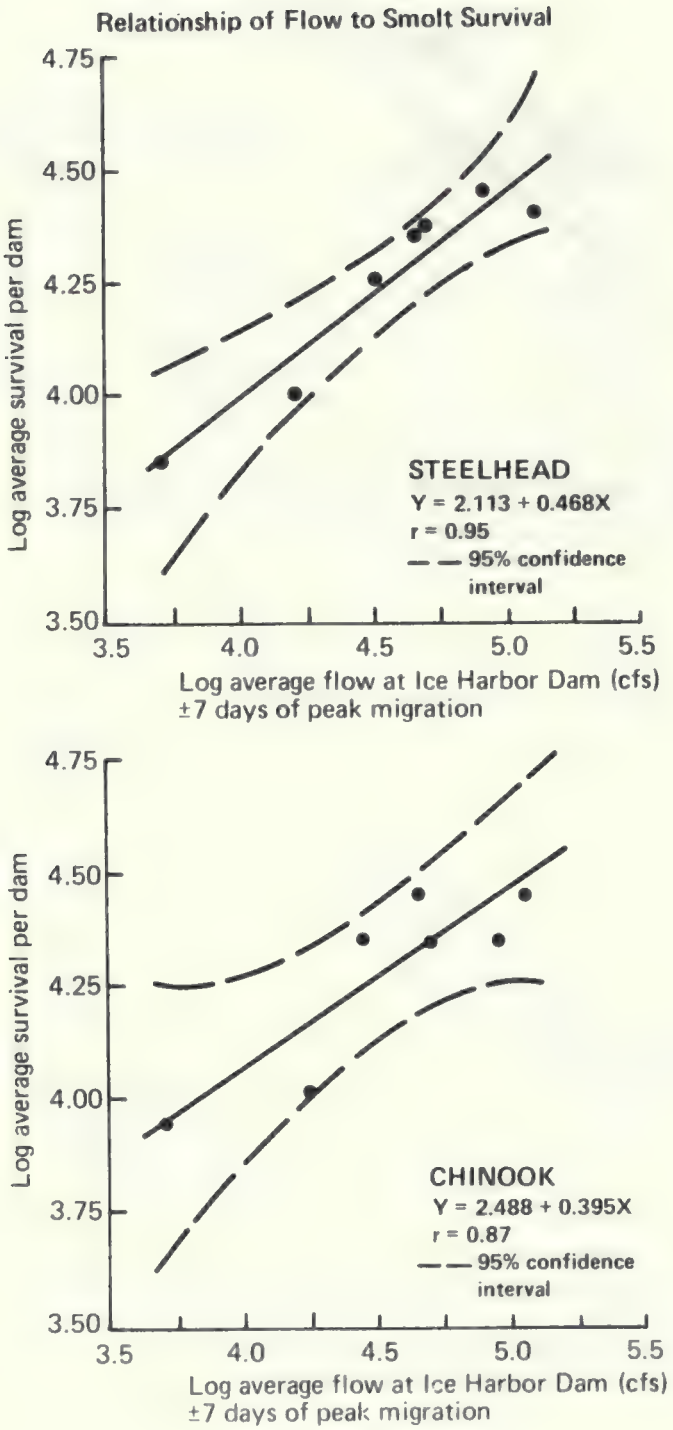
1/ At migration peak ± 7 days.

Attachment 1

Table 1.--Predicted travel time for yearling chinook salmon and steelhead smolts from Lower Granite Dam to The Dalles Dam, given various flow levels.[a/]

Flow(cfs x 1000)	Predicted travel time			
	Avg. per project (days)		Lower Granite to The Dalles Dam (days)	
	Chinook	Steelhead	Chinook	Steelhead
50	5.0	4.7	30	28
75	3.6	3.5	22	21
100	2.8	2.8	17	17
125	2.3	2.4	14	14
150	2.0	2.1	12	12
175	1.8	1.8	11	11

[a/] Avg. flow at Ice Harbor Dam during migration peak (± 7 days).



Attachment 1
Figure 2.--Regression line for river flow at Ice Harbor Dam and survival of Snake River yearling chinook salmon and steelhead smolts, 1973-1979.

Attachment 1

Table 2.--Predicted smolt survival at various levels of flow at Ice Harbor Dam at the time of peak migration.[a/]

River flow[a/] (cfs x 1000)	Predicted survival to The Dalles Dam	
	Chinook (%)	Steelhead (%)
40	2	1
60	5	3
80	10	7
100	16	13
120	26	23
140	38	33
160	50	50
180	69	69

[a/] Average flow during the period ± 7 days from migration peak.

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Task 1.1.1: Provide a minimum flow regime to improve survival of migratory juvenile salmonids in the Columbia River Basin based on current biological knowledge and water management constraints.

Introduction: The initial fishery flow regime recommended by the fishery agencies reflects an attempt to balance between the protection, mitigation, and enhancement of fisheries and adaquate efficient economical and reliable power supply. Under the fishery flow regime, fish and power needs will be met when water supplies are good, while both will be limited under dry water conditions. Considerable analysis of present river system management was required to develop the fishery flow recommendation. Five major uses groups form the foundation and basic requirements of the management system. These are flood control irrigation, recreation, electric power production, and fisheries. All these interests share a common contingency based on annual volume runoff for the Columbia Basin.

In considering the requirements of each of these uses groups, irrigation was the most insulated against and least affected by variations in annual volume runoff. This insulation occurs due to established water rights which are not related to volume runoff. Modeling analysis of the Columbia System therefor considers irrigation requirements as a constant, varying only with level of development.

The remaining four requirements, flood control, recreation, power production, and fisheries were analyzed in terms of impacts when one interest was served over the others. Again, the common factor was annual volume runoff. Generally, when runoff conditions are average or better, the requirements of all users can be met. Conflicts arise when less than average runoff volumes occur.

Each major interest group has an extremely complex aggregation of requirements and constraints. However, a simplified description aids in understanding the general concerns.

The natural hydrograph of the Columbia system has been changed drastically by storage regulation. Historical spring freshets are essentially eliminated. The flows that once comprised the spring freshet are stored for use during winter months when demand for power is high. This regulation mode is a real benefit to power production and citizens of the Northwest that depend on the production. Storage reservoirs such as Hungry Horse and Libby have created huge lakes which are regulated for power production. They are filled in the spring and water is stored through the summer. In the fall, as power demand increases, water is released to produce power and the reservoirs begin to empty. This regime has benefits for various aspects of life in the Northwest.

In contrast to power regulation, fishery needs require river conditions similar to the natural hydrograph. Upriver salmon and steelhead generally begin their upstream adult migration in early spring and continue into fall. Fish spawn in the late summer and fall. Juvenile fish rear in the river for up to two years. The downstream juvenile migration begins in early spring and continues into the summer. Historically, the downstream migration depended on the spring freshet. The downstream migration has been altered as the spring freshet has been altered by storage regulations.

Dry years and subsequent low flows result in unfilled reservoirs, decreased power production, and more adverse conditions for juvenile migrating salmonids. The purpose of our analysis was to formulate an interim solution to this problem which.

Minimum Flow Recommendations for Juvenile Salmon and Steelhead Migrants in the Columbia River Basin

1. Recommend minimum fishery flows are presented in Table 1. These tabulated Recommended minimum Fishery Flows (RMFF) shall be implemented on April 15th of each year. The level of fishery flows is contingent upon the January-July volume runoff forecast at Priest Rapids and Lower Granite Dams.

2.a. Priest Rapids Dam

TABLE 1

RECOMMENDED WEEKLY MINIMUM FLOWS
X 1000 CFC

Month	Lower Granite	Priest Rapids	The Dalles
January	20	70	60
February	20	70	60
March	20	70	60
April			
1-15	40	70	120
16-25	85	70	160
26-30	85	110	200
May	85	130	220
June			
1-15	85	110	200
16-30	30	80	120
July			
1-15	30	80	120
16-31	20	110	140
August	20	95	120
September	20	40	90
October			
1-15	20	40	90
16-31	20	70	90
November	20	70	60
December	20	70	60

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When the April 1 (January-July) forecast at Priest Rapids Dam is projected to be less that 65 MAF the recommended minimum fishery flows will be reduced in accordance with Figure 1 and Table 2 (Figures 1 and 2 show approximate increases and decreases from the RMFF). This reduction is applied at a rate of 1 percent for every one MAF forecasted below 65 MAF. The maximum reduction allowed shall be 25 percent or 36,000 cfs, whichever is greater for water years of 40 MAF and less. Tables 2 and 3 contain the modified RMFF based upon volume runoff.

When the April 1 (January-July) forecast at Priest Rapids Dam is greater than 75 MAF, the recommended minimum fishery flows will be increased in accordance with Figure 1 and Table 2. This increase shall be applied at the rate of 1.5 percent for every one MAF forecasted above 75 MAF for the period April 16 through June 15. The maximum increase shall be limited for fishery purposes to 15 percent for water years of 85 MAF and greater.

b. Lower Granite Dam

When the April (January-July) forecast at Lower Granite Dam is projected to be less than 20 MAF the recommended minimum fishery flows will be reduced in accordance with Figure 2 and Table 3. This reduction is applied at a rate of 5 percent for every one MAF forecasted below 20 MAF. The maximum reduction allowed shall be 25 percent for water years of 15 MAF and less.

When the April 1 (January-July) forecast at Lower Granite Dam is than 20 MAF, the recommended fishery flows will be increased in accordance with Figure 2 and Table 3. This increase shall be applied at the rate of 6.5 percent for every one MAF forecasted above 25 MAF for the period April 16 through June 15. The maximum increase shall be limited for fishery purposes to 65 percent for water years of 30 MAF and greater.

c. The Dalles Dam

PRIEST RAPIDS DAM
FISHERY FLOW RECOMMENDATIONS

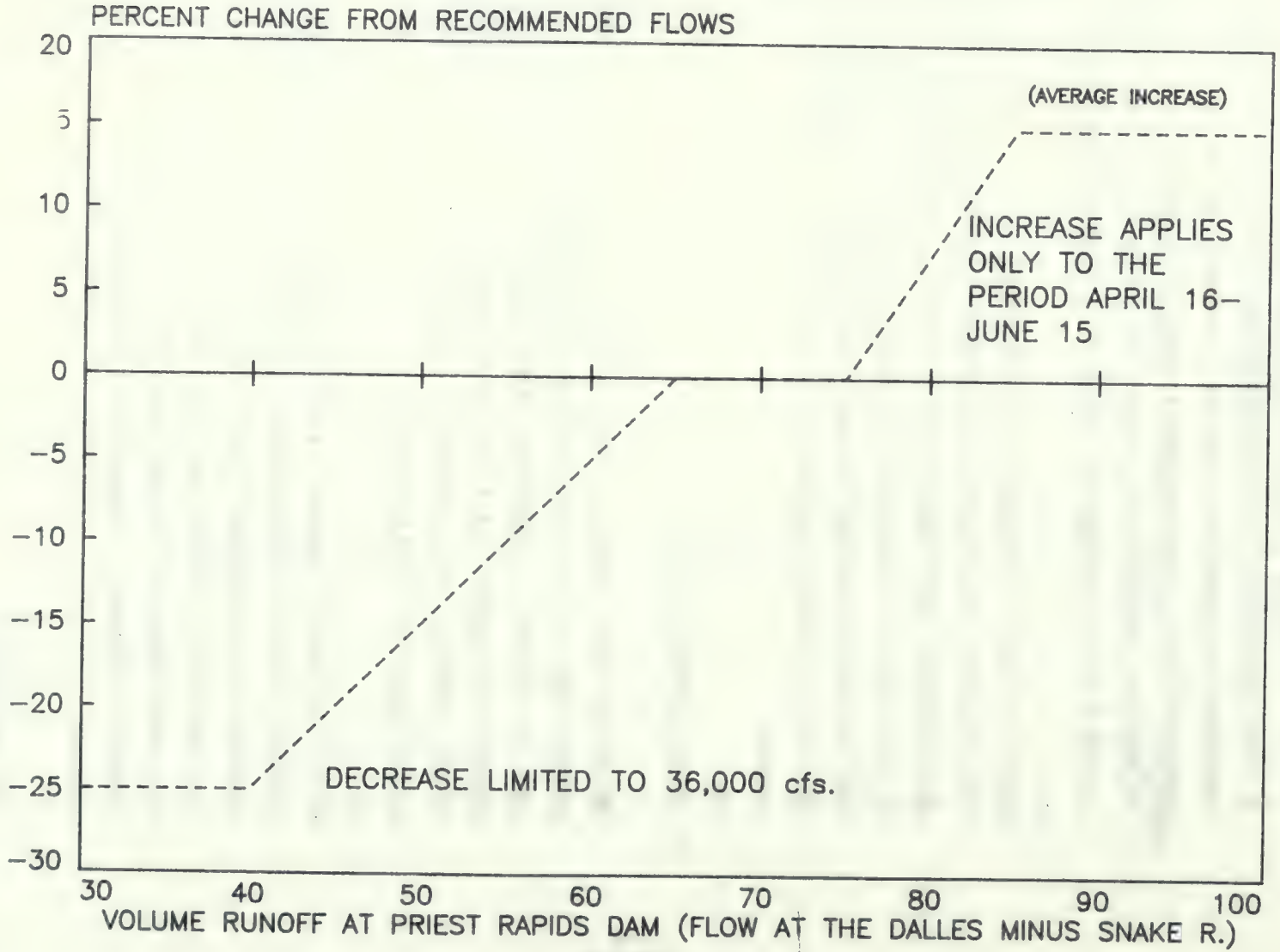


FIGURE 1

LOWER GRANITE DAM
FISHERY FLOW RECOMMENDATIONS

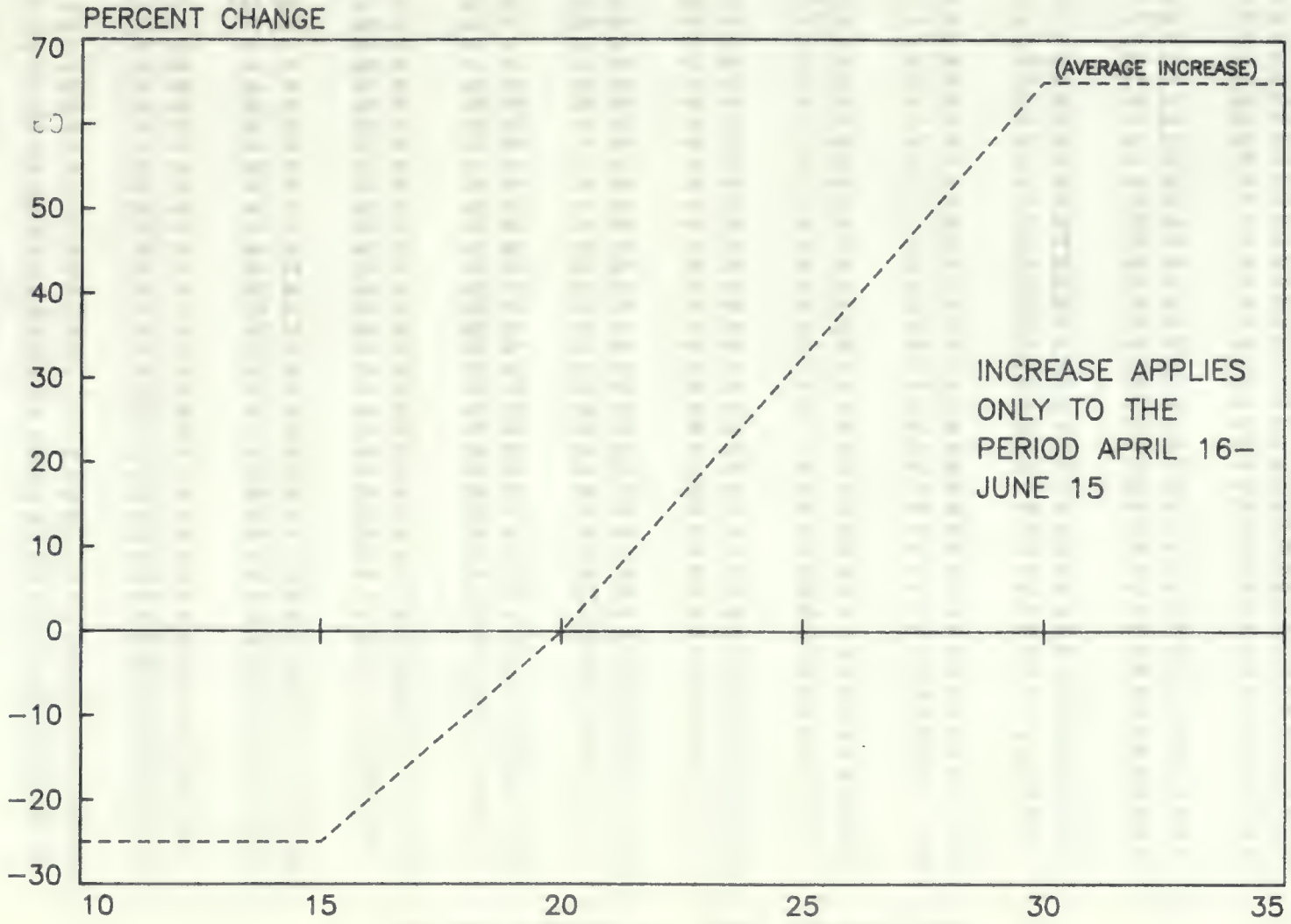


FIGURE 2

TABLE 2.-- PRIEST RAPIDS DAM
FISHERY FLOW RECOMMENDATIONS

MAF	APR2	MAY	JUN	JUL	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1
40.0	62.48	97.50	71.25	71.63	71.25	71.25	36.00	41.63	52.50	52.50	52.50	52.50	52.50	52.50
41.0	63.31	98.80	72.20	72.58	72.20	72.20	36.00	42.18	53.20	53.20	53.20	53.20	53.20	53.20
42.0	64.14	100.10	73.15	73.54	73.15	73.15	36.00	42.74	53.90	53.90	53.90	53.90	53.90	53.90
43.0	64.97	101.40	74.10	74.49	74.10	74.10	36.00	43.29	54.60	54.60	54.60	54.60	54.60	54.60
44.0	65.81	102.70	75.05	75.45	75.05	75.05	36.00	43.85	55.30	55.30	55.30	55.30	55.30	55.30
45.0	66.64	104.00	76.00	76.40	76.00	76.00	36.00	44.40	56.00	56.00	56.00	56.00	56.00	56.00
46.0	67.47	105.30	76.95	77.36	76.95	76.95	36.00	44.96	56.70	56.70	56.70	56.70	56.70	56.70
47.0	68.31	106.60	77.90	78.31	77.90	77.90	36.00	45.51	57.40	57.40	57.40	57.40	57.40	57.40
48.0	69.14	107.90	78.85	79.27	78.85	78.85	36.00	46.07	58.10	58.10	58.10	58.10	58.10	58.10
49.0	69.97	109.20	79.80	80.22	79.80	79.80	36.00	46.62	58.80	58.80	58.80	58.80	58.80	58.80
50.0	70.81	110.50	80.75	81.18	80.75	80.75	36.00	47.18	59.50	59.50	59.50	59.50	59.50	59.50
51.0	71.64	111.80	81.70	82.13	81.70	81.70	36.00	47.73	60.20	60.20	60.20	60.20	60.20	60.20
52.0	72.47	113.10	82.65	83.09	82.65	82.65	36.00	48.29	60.90	60.90	60.90	60.90	60.90	60.90
53.0	73.30	114.40	83.60	84.04	83.60	83.60	36.00	48.84	61.60	61.60	61.60	61.60	61.60	61.60
54.0	74.14	115.70	84.55	85.00	84.55	84.55	36.00	49.40	62.30	62.30	62.30	62.30	62.30	62.30
55.0	74.97	117.00	85.50	85.95	85.50	85.50	36.00	49.95	63.00	63.00	63.00	63.00	63.00	63.00
56.0	75.80	118.30	86.45	86.91	86.45	86.45	36.40	50.51	63.70	63.70	63.70	63.70	63.70	63.70
57.0	76.64	119.60	87.40	87.86	87.40	87.40	36.80	51.06	64.40	64.40	64.40	64.40	64.40	64.40
58.0	77.47	120.90	88.35	88.82	88.35	88.35	37.20	51.62	65.10	65.10	65.10	65.10	65.10	65.10
59.0	78.30	122.20	89.30	89.77	89.30	89.30	37.60	52.17	65.80	65.80	65.80	65.80	65.80	65.80
60.0	79.14	123.50	90.25	90.73	90.25	90.25	38.00	52.73	66.50	66.50	66.50	66.50	66.50	66.50
61.0	79.97	124.80	91.20	91.68	91.20	91.20	38.40	53.28	67.20	67.20	67.20	67.20	67.20	67.20
62.0	80.80	126.10	92.15	92.64	92.15	92.15	38.80	53.84	67.90	67.90	67.90	67.90	67.90	67.90
63.0	81.63	127.40	93.10	93.59	93.10	93.10	39.20	54.39	68.60	68.60	68.60	68.60	68.60	68.60
64.0	82.47	128.70	94.05	94.55	94.05	94.05	39.60	54.95	69.30	69.30	69.30	69.30	69.30	69.30
65.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
66.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
67.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
68.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
69.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
70.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
71.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
72.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
73.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
74.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
75.0	83.30	130.00	95.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
76.0	85.97	131.00	96.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
77.0	88.64	132.00	97.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
78.0	91.31	133.00	98.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
79.0	93.98	134.00	99.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
80.0	96.65	135.00	100.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
81.0	99.32	136.00	101.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
82.0	101.99	137.00	102.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
83.0	104.66	138.00	103.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
84.0	107.33	139.00	104.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
85.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
86.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
87.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
88.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
89.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00
90.0	110.00	140.00	105.00	95.50	95.00	95.00	40.00	55.50	70.00	70.00	70.00	70.00	70.00	70.00

TABLE 3.-- LOWER GRANITE DAM
FISHERY FLOW RECOMMENDATIONS

MAF	APR2	MAY	JUN	JUL	AUG1	AUG2	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR1
15.0	63.75	63.75	43.13	18.60	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	30.00
15.5	65.88	65.88	44.56	19.22	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50	31.00
16.0	68.00	68.00	46.00	19.84	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	32.00
16.5	70.13	70.13	47.44	20.46	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	33.00
17.0	72.25	72.25	48.88	21.08	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	34.00
17.5	74.38	74.38	50.31	21.70	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	35.00
18.0	76.50	76.50	51.75	22.32	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	36.00
18.5	78.63	78.63	53.19	22.94	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	37.00
19.0	80.75	80.75	54.63	23.56	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	38.00
19.5	82.88	82.88	56.06	24.18	19.50	19.50	19.50	19.50	19.50	19.50	19.50	19.50	19.50	39.00
20.0	85.00	85.00	57.50	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
20.5	86.50	87.75	59.88	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
21.0	88.00	90.50	62.25	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
21.5	89.50	93.25	64.63	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
22.0	91.00	96.00	67.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
22.5	92.50	98.75	69.38	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
23.0	94.00	101.50	71.75	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
23.5	95.50	104.25	74.13	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
24.0	97.00	107.00	76.50	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
24.5	98.50	109.75	78.88	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
25.0	100.00	112.50	81.25	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
25.5	101.50	115.25	83.63	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
26.0	103.00	118.00	86.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
26.5	104.50	120.75	88.38	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
27.0	106.00	123.50	90.75	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
27.5	107.50	126.25	93.13	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
28.0	109.00	129.00	95.50	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
28.5	110.50	131.75	97.88	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
29.0	112.00	134.50	100.25	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
29.5	113.50	137.25	102.63	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
30.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
30.5	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
31.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
31.5	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
32.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
32.5	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
33.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
33.5	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
34.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
34.5	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00
35.0	115.00	140.00	105.00	24.80	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	40.00

Recommended minimum fishery flows for The Dalles Dam are presented in Table 1. During years when reduced flows are required at both Priest Rapids and Lower Granite Dams, the recommended fish flow requirements at The Dalles must also be reduced.

3. The fishery agencies acting through the permanent staff may opt for no fish flow reduction, based upon biological considerations, for a single year in lieu of obtaining any minimum fish flows the following year. Should the system refill in the year the agencies opted for full recommended flows, flow reductions the following year would be based upon the volume runoff forecast as stated above.

4. During a year when the flows contained in Table 1 are allocated at a reduced level, the fishery agencies will attempt to shape these reduced flows within a given period in a manner to improve fish survival while impacting the power system for as short a duration as practical. The effect of this would be to provide the recommended minimum fishery flows but for a shorter duration.

5. The flows contained in Table 1 are monthly average but may be shaped to be either daily or weekly average flows. Weekly average flows are supported by the National Marine Fisheries Service, Fish and Wildlife Service, and the States of Oregon, Washington and Idaho. Daily average flows are recommended by the Yakima, Umatilla, Warm Springs, and Nez Perce Tribes.

6. Should the system fail to refill by July 31, the recommended minimum fishery flows for the period July 31 through April 15 will continue at the reduced level specified in paragraph 2 above. In years when the system fills by July 31, the recommended fishery flows shall be implemented until April 15 of the following year.

Discussion: Upon receipt of the request for recommendations from the Regional Power Council, and Instream Flow Work Group was formed to develop a common data base of information on river regulation and its impacts on the power system. The work group consists of staff from the Corps of

Engineers, Bonneville Power Administration, National Marine Fisheries Service, Columbia River Fisheries Council, Bureau of Reclamation, and the Pacific Northwest River Basins Commission. Studies were made on the river regulation model used by the Corps of Engineers.

The 1985 level of development for power and irrigation has been selected for the studies because it represents a year in the near future which fishery flows could be implemented into the planning process by the power interests on an annual basis. Forty years of historical flow records (1929 to 1968) are used in all of these studies. Three control points are established at which desired fishery flow levels can be varied, depending upon the desired outcome. The three control points are Lower Granite for the Snake River system, Priest Rapids for the mid-Columbia River and The Dalles for the lower Columbia River. Different regulation studies include various participating reservoirs so that their contribution to fishery flows can be noted. Refer to Tables 2 and 3 for study summaries. Most studies included only the Federal reservoirs participating in providing fishery flows and excluded others such as Brownlee and Canadian reservoirs. (This constraint may be somewhat artificial, since it does appear that Canadian reservoirs can be drafted for fish flows.) The original intent was to base fishery flow recommendations on volume runoff forecasts at The Dalles similar to that used by the power interests. After analyzing many studies it became apparent that more localized forecasts would be needed. As discussed below, our recommendations are based upon two forecasts, one at Lower Granite, and one at Priest Rapids. Note: The forecast used in this analysis for Priest Rapids is the forecast at The Dalles minus the forecast at Lower Granite. To arrive at this point though, base studies were developed.

Input data into each study include initial reservoir contents, estimated loads, the historical record of streamflows at each hydro site for a 40-year period, irrigation withdrawals, the plant characteristics of each project and operating guidelines. Non-power requirements such as flood control, navigation irrigation, fisheries, wildlife, and recreation are incorporated to some degree in these studies. Details of the model used for these studies are not included in this report, but may be obtained from the North Pacific Division of the Corps of Engineers, Portland, Oregon.

Two hydro regulations were made of each study (except refill studies). These consist of a critical-period regulation to established rule curves and a 40-year regulation. The critical period is defined as that portion of the historical 40-year streamflow record which, when combined with draft of all available reservoir storage, will produce the least amount of energy, with energy shaped to the load. All reservoirs are assumed to be full at the beginning of the critical period and empty at the end. In accord with the Pacific Northwest Coordination Agreement, this level of energy is the "firm energy capability" of the hydro system. Firm hydro capability thus is derived from a computation that assumes the most critical streamflows and full used of reservoir storage. Power regulation studies usually indicate the critical period as the 42½-month period from August 16, 1928 through February 1932.[1/]

In order to quantify the effects of adding in fishery flow requirements on the power system, a base case study was prepared. The base case is how the system would be run for power, irrigation and recreation. The loads used in all of the studies were obtained from the 1981 West Group Forecast, updated by BPA with the latest load information. A critical-period study was made by Bonneville Power Administration to establish the operating rule curves. The rule curves were then applied to the Corps of Engineers model and a 40-year continuous regulation was made. This base study is referred to as the "F" study. All subsequent studies are related to "F" study.

To study the effect of including fishery flow constraints in the system regulation, the Columbia River Fisheries Council's recommended minimum flows were added to the model (2). This study was run twice, with (Study "M") and without (Study "N") Brownlee Reservoir participating in the fish flow operation.

A tabular summary of these studies is contained in Tables 4 and 5. In running these various studies for fish flows, a decision was make for each study as to which storage reservoirs would be included in assisting for fish flows. In general, only the federal reservoirs--Libby, Dworshak, and Hungry Horse--were used.

TABLE 4

SUMMARY OF INSTREAM FLOW STUDIES - 1985 LEVEL

PROBABILITY OF MEETING FISH FLOWS - %

STUDY	STUDY OBJECTIVE	All 560 Periods			April, May and June			May			Number of Years During the 40-Yr. Period Reservoir is not at Full Pool on July 31						Firm Load Reduction From "F" Study - MW
		Priest Rapids	Lower Gr.	The Dalles	Priest Rapids	Lower Gr.	The Dalles	Priest Rapids	Lower Gr.	The Dalles	Brown-lee	Dwor-shak	Libby	Grand Coulee	Canadian	Hungry	
8185F	Base Study	84	77	83	69	59	64	48	60	50	2	14	8	7	13	11	
												Deviation From Base Period					
M	Libby, Dworshak, Brownlee & Hungry Horse only for flows	96	93	96	93	94	93	83	93	88	9	13	7	0	N/A	10	3750
V	Variable Flow Based on Runoff	100	100	N/A 1/	100	100	N/A 1/	100	100	N/A 1/	2	11	4	4	N/A	7	180
		91	80	89 2/	86	79	83 2/	78	75	70 2/							
Y1		-	-	-	-	-	-	70	60	65 3/	6	15	10	5	N/A	11	780

1/ These represent the percent of time the resultant flows in Study "V" coincided with the fishery flows, including reductions.

2/ These represent the percent of time the resultant flows in Study "V" & "Y1" coincided with the fishery flows without reductions. These percentages are related to the same base fishery flows as the "F" and "M" Studies.

3/ These flows were not targeted at these dams, the control was set at McNary Dam. The required targeted flows at McNary Dam were met in all 560 periods.

Table 5

SUMMARY OF INSTREAM FLOW STUDIES - 1985 LEVEL

PROBABILITY OF MEETING FISH FLOWS - %

		All 560 Periods			April, May and June			May			Number of Years During the 40-Yr. Base Reservoir is not at Full Pool on July 31						
DY	STUDY OBJECTIVE	Priest Rapids	Lower Gr.	The Dalles	Priest Rapids	Lower Gr.	The Dalles	Priest Rapids	Lower Gr.	The Dalles	Brown-lee	Dwor-shak	Libby	Grand	Canadian	Hungry	Firm Load Reduction From "F" Study - MW
85F	Base Study	84	77	83	69	59	64	48	60	50	2	14	8	7	13	1	
												Deviation		From	Base		
N	Libby, Dworshak & Hungry Horse only for flows	95	86	95	93	76	90	83	78	85	0	14	6	0	1	10	3750
Q	Fixed Snake Flows & Variable Main-stem flows	100	98	N/A	100	94	N/A	100	95	N/A	4	11	2	1	0	5	320
R	All Projects to meet flows	100	94	100	100	95	100	100	95	100	9	12	0	3	-3	3	3770
S	No Flood Control	99	94	99	98	96	98	98	93	98	9	3	3	4	1	4	3220
W	Variable Flow Based on Runoff	100	100	N/A	100	100	N/A	100	100	N/A	1	11	2	3	-1	10	130

Tables 4 and 5 tabulate the probability of meeting fish flows in the periods specified, the number of years specific reservoirs failed to refill, and the firm load reduction in megawatts (mw) over the 40-year period for all of the studies conducted at the 1985 level of development.

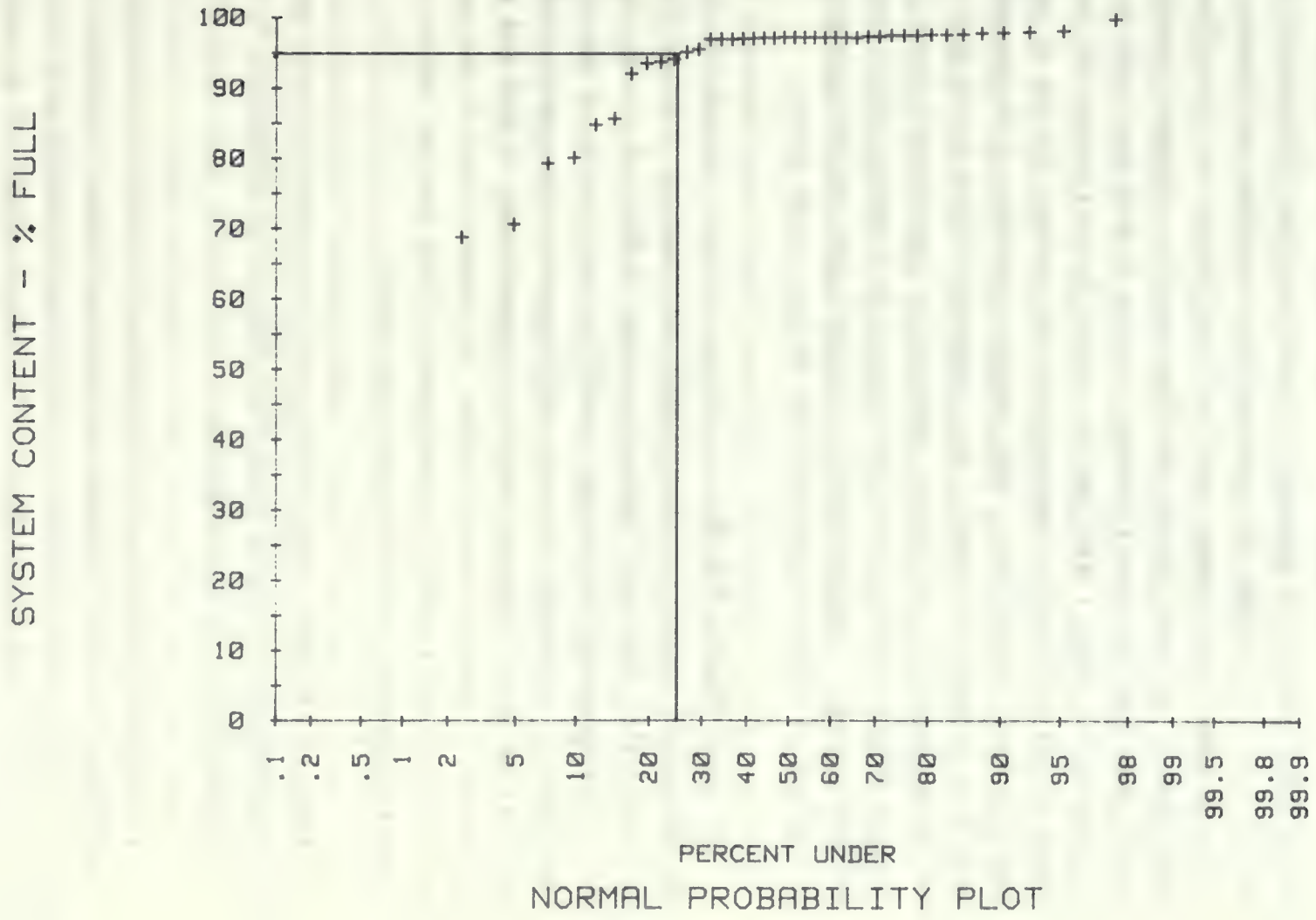
A third study was run with the Columbia River Fisheries Council minimum flow recommendations. This study used all projects, including Canadian storage, to meet fishery flows. This is study "R". The load reduction for these three studies is approximately 3,750 mw. Upon inspection of the studies, it can be noted that this firm load reduction occurred in low volume runoff years and over a 4 to 5-month period. It was not just a "spike" during the critical period. More discussion is contained in the Impacts section of this sub-objective and Appendix-BB.

The flow recommendations made in this subsection were based upon the probability of occurrence of low-water years. Figure 3 is the probability plot of historical volume runoff for the period 1929 to 1968. Figure 4 is a probability plot of system refill for study "F", the agreed upon base study, Figure 4, shows that more than 75 percent of the 40-year study period the system refills more than 95 percent or greater. Using the same probability of occurrence, 75 percent, it was found that a volume runoff of approximately 82.5 MAF (January-July) or greater would occur at The Dalles (See Figure 3). This volume runoff of 82.5 MAF at The Dalles was used in one of the studies to attempt to bracket flow reductions and their impact on firm load. This was study "V". In analyzing study "V" and the flow reductions it became apparent that the volume runoff in the Snake system is not always in phase with the Columbia. This discrepancy lead to the separation of the Snake forecast from the Columbia forecast. It was felt that by doing this and removing the control at The Dalles when the two systems were out of phase a more optimum solution to fishery flows and power production could be found. The 75 percent probability of occurrence for low volume runoff at Priest Rapids and Lower Granite Dams are 62.5 MAF and 22.1 MAF respectively.

In formulating the flow recommendations, it was assumed that fishery flows would be provided at the 100 percent level and greater when the volume runoff is forecasted to be greater than 65 MAF at Priest Rapids and greater

Figure 3 - THE DALLES 1929-1968
NORMAL PROBABILITY PLOT
PERCENT UNDER
.1
.2
.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.8
99.9
50
60
70
80
90
100
110
120
130
140
150
JANUARY-JULY RUNOFF (M.R.F.)

Figure 4 - BASE STUDY 85-F



than 20 MAF at Lower Granite. An accommodation was them made for those runoff years which were expected to occur less than 25 percent of the time. Figures 1 and 2 illustrate the proposed flow reductions and average flow increases based upon volume runoff at Priest Rapids and Lower Granite respectively. At Priest Rapids fish flows would be reduced 1 percent for every 1 MAF that the runoff forecast is below 65 MAF and would be increased 1.5 percent for every 1 MAF that the runoff forecast exceeds 75 MAF. A volume runoff of 75 MAF is approximately the average for the 40 years of record at Priest Rapids Dam. The maximum reduction of 25 percent would occur at a forecast of 40 MAF. Any forecasted volume runoff less than 40 MAF would result in a 25 percent reduction in recommended flows. The maximum increase of 15 percent would occur at a volume runoff forecast of 85 MAF and greater. Volume runoffs of approximately 85 MAF and greater can be expected to occur 25 percent of the 40-year study period.

At Lower Granite fish flows would be reduced 5 percent for every 1 MAF that the runoff forecast is below 20 MAF and would be increased 6.5 percent for every 1 MAF the runoff forecast exceeds 20 MAF. A volume runoff of 25 MAF is approximately the average runoff for the 40 years of record on the Snake River. A maximum reduction of 25 percent would occur at a forecast of 15 MAF or lower. Volume runoffs of approximately 30 MAF and greater can be expected to occur at Lower Granite, 25 percent of the 40-year study period and volume runoff of approximately 20 MAF and less can be expected to occur 25 percent of the 40-year study period.

Flows at The Dalles shall be the base recommended fishery flows which will be implemented in those years when there is no modification to the flows at at Lower Granite or Priest Rapids.

Volume runoffs which, in the 40 years of record, have occurred at a probability of less than 25 percent are the years when reductions will take place. Volume runoffs between the 25 percent probability and the mean runoff years are the years when the recommended flows will be implemented. These two periods where recommended flows or less are to be implemented occurred at and below the 50 percent probability of occurrence of the 40 years studied. Reduced flows shall be implemented in all periods of the year.

Increases in the recommended flows shall start in those years which the volume runoff is forecasted to be greater than the mean runoff from the 40-year study period. The maximum increase corresponds to flows which the fishery agencies consider optimum flows. No increase in flows is requested for fishery needs above the optimum level. These increases correspond to volume runoffs from the 40-year record between the mean and the 75 percent probability of occurrence. These increases are requested only for the period April 16 through June 15. The recommended flows will be implemented from June 16 through April 15. This implementation period for increased flows is subject to change based upon research conducted under the Section 4(h) program. Illustrations of the probability plots of volume runoff at Priest Rapids and Lower Granite Dams are contained in Figures 5 and 6.

The recommendations stated above were not modeled due to the time constraint of submitting this document by November 15, 1981. What is presented here is an attempt to accommodate all needs given the full range of expected runoff conditions and some general statements on anticipated impacts associated with these recommendations. A follow-up report with these recommendations analyzed by using both the Corps model and the newly developed BPA model will be provided to the Regional Power Council as soon as possible.

Several results are shown in Tables 4 and 5. The study which most closely approximates our recommendations is one which was run over a year ago for the Washington State Department of Ecology (DOE) by the Corps of Engineers. This study was made at the 1995 level of development, not the 1985. Calibration type studies were made recently to show that there was little difference in hydro regulation studies at the 1985 and 1995 levels so that the 1995 level studies can be assumed to have the same impact as the 1985 level studies. The DOE study is referred to as the YI study. The control for this study was at McNary Dam. The intent by DOE was to reduce fishery flows on the Columbia and to limit future water rights based upon the same reduction rationale (3). Attention was not given to the Snake River since the State has not control on flows eminating from the storage reservoirs in Idaho.

Figure 5 - PRIEST RAPIDS
NORMAL PROBABILITY PLOT
PERCENT UNDER
JANUARY-JULY RUNOFF (M.A.F.)
Optimum flow level
Increased flows
Mean Runoff
Recommended flows
Reduced flows
110
100
90
80
70
60
50
40
30
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
.5
.2
.1

Figure 6 - LOWER GRANITE
NORMAL PROBABILITY PLOT
PERCENT UNDER
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
.5
.2
.1
Optimum flow level
Increased flows
Mean Run-off
Recommended flows
Reduced flows
50
40
30
20
10
JANUARY-JULY RUNOFF (M.A.F.)

Therefore, suggesting that the Y1 study accurately depicts the flow recommendations is not correct, yet it is the closest representation of the fishery recommendations and is presented for discussion purposes.

Impacts

The fishery flow recommendations represent a balance of impacts to refill, power generation, and fish flows. As noted earlier, 75 percent of the time there will be essentially no adverse impact to any of the users because the probability of runoff in each basin is used in calculating fishery flow recommendations. It is the 25 percent of the one-year-in-four occurrence where some equitable accommodation must be made to all user groups. Irrigation requirements were not altered in low-water years, so no adverse impact was identified.

The impact to power generation was viewed in terms of impact to firm load only. Secondary and surplus generation were not thoroughly analyzed in this report but some general statements can be made.

Figure 7 shows a Summary of Generation in the critical period and for the 40-year study period. This figure also contains the average surplus energy and the average usable secondary energy. In the Generation Summary, it should be noted that the average generation was not significantly impacted by fishery flows. Surplus energy increased as expected with fishery flows, but what is not shown in this figure is that the distribution was changed significantly with fish flows. The impact of this shift is not analyzed. No direct attempt was made in these studies to shift thermal maintenance to accommodate fish flows.

The power and recreation impacts of major importance to the region from providing the recommended fishery flows are firm load reduction (thermal decrement), and reservoir refill. These impacts are summarized in Tables 4 and 5. Table 2 is discussed in Appendix BB.

Study "F," ie base case, was run to meet loads in the region. With the resultant flows from Study "F," the percent of time they coincide with the

CONTROL POINTS
AVERAGE ENERGY
Megawatts

Study	Priest Rapids		Lower Granite		The Dalles	
	C.P.	40 Yr.	C.P.	40 Yr.	C.P.	40 Yr.
F	492	604	217	326	740	992
V	491	605	217	327	739	992
Y1	498	605	211	321	738	939

TOTAL SYSTEM (40 Year Average)
Megawatts

Study	Hydro Gen.	Surplus	Usable Secondary
F	14707	3412	2476
V	14672	3557	2554
Y1	14627	4229	2543

Figure 7.

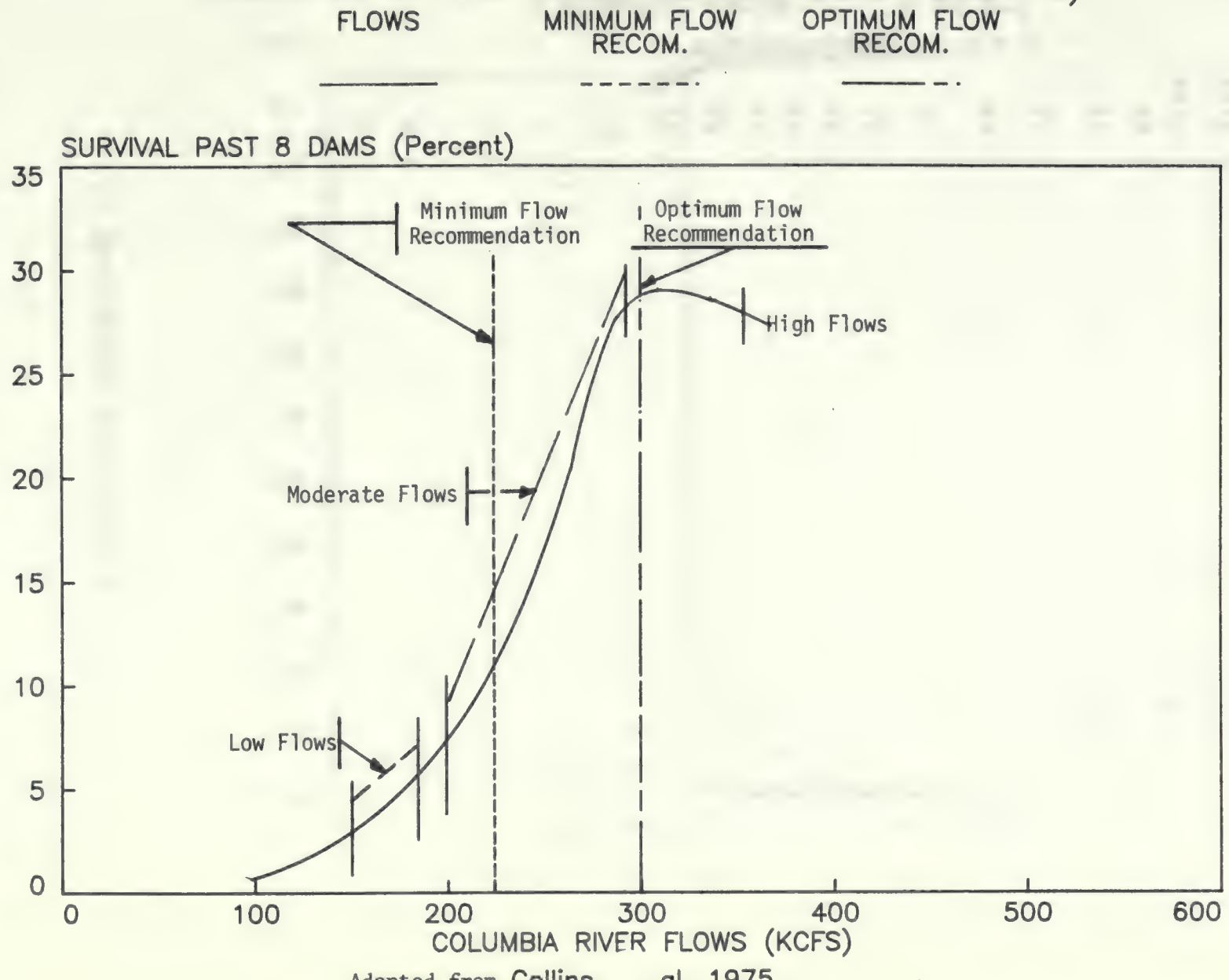
recommended fishery flows in all 560 periods (40 years x 14 periods = 560) is greater than 80 percent at Priest Rapids and The Dalles. The flows at Lower Granite are relatively lower, closer to 75 percent. The conflict between power production and fishery flows is greatest during the spring months as discussed earlier. The months of April, May and June are separated out so that a better perspective can be gained in comparing these studies. The month of May is particularly important for fish flows, so it is highlighted. The resultant flow comparison in the spring months for the "F" Study shows a 50 to 60 percent probability of meeting fish flows. The refill for the seasonal reservoirs in the system is shown in terms of number of years out of the 40-year study period they failed to refill. The refill columns give no information on how close these reservoirs may have come to refilling though. Examination of the computer study will yield this information and it is not presented in this document except for study "F." See Figure 4.

Referencing Exhibit 1 in Subobjective 1.1, it should be noted that the recommended fishery flows contained in this report coincide with the dashed vertical line for flows of 220,000 cfs measured at The Dalles. The corresponding flows at Priest Rapids and Lower Granite contained in Table 1 yield an approximate survival of 10 percent passing eight dams. Smolts migrating from the Snake system pass eight dams and smolts from above Wells Dam on the Columbia must pass nine dams.

Reduced flows at Priest Rapids and Lower Granite drop the survival into the 3 to 5 percent range. Increased flows in the spring during wet years increases the survival to approximately 30 percent. The impact of low runoff years is significant to the fishery resource.

Fishery flows have a definite impact on reservoir refill. The largest impact is on the Snake River. In the "V" Study for instance, Dworshak fails to refill 25 years out of 40 years or 65 percent of the time. A comparison of refill probability between the F and V studies at Dworshak is shown in Figure 8. This would be a major impact and points out the need for further studies on the Snake system. Libby fails to refill 12 out of 40 years or 30 percent of the time. The Y1 Study, which controlled flows only at McNary Dam, shows a much smaller impact on system refill. Figure 9 is a combined plot of the

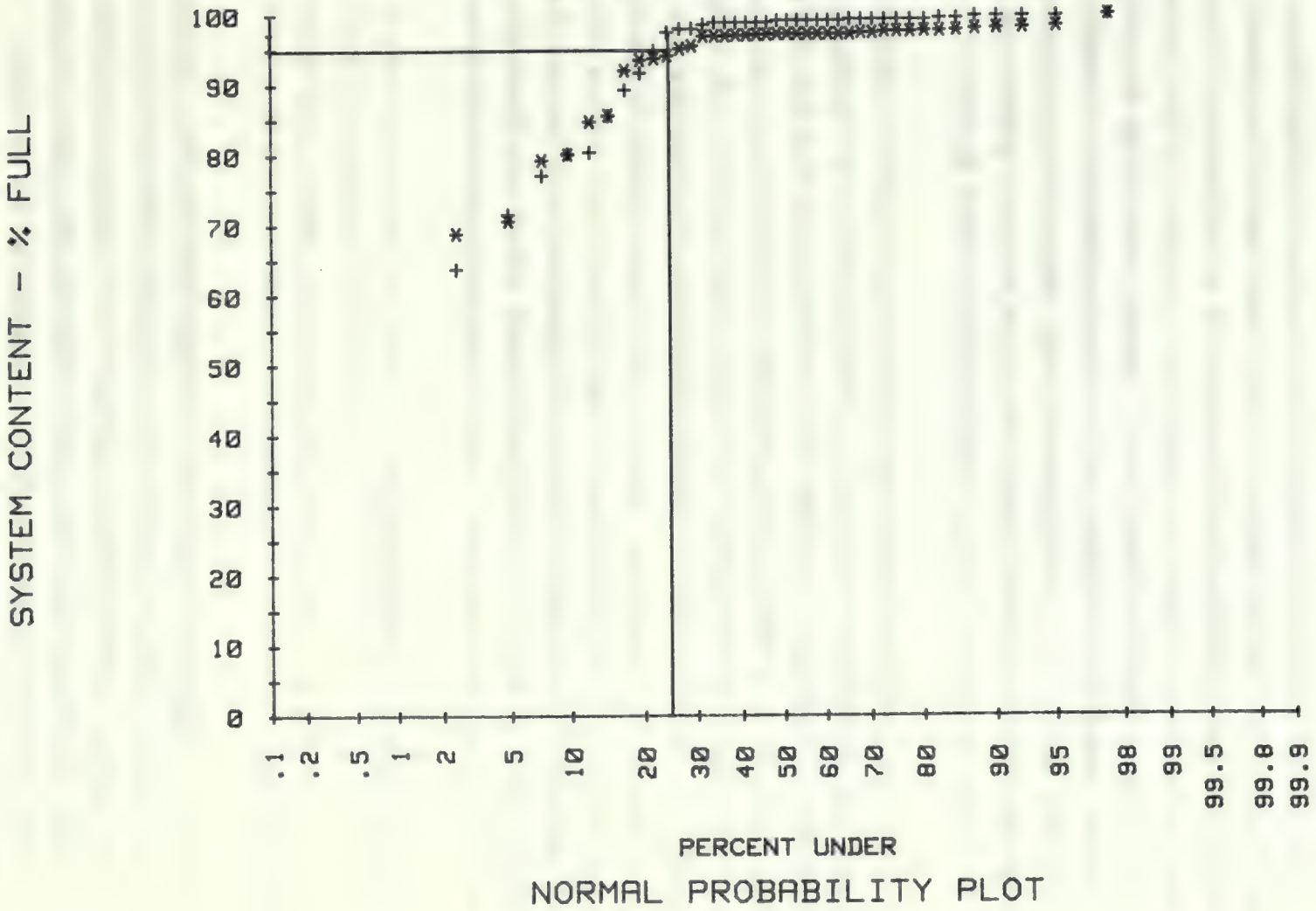
EXHIBIT 1.--Flow survival relationship. (Flow measured at The Dalles--survival data 1966-75)



Adopted from Collins, al, 1975

Figure 8 - V (+) & F (*)
NORMAL PROBABILITY PLOT
PERCENT UNDER
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
.5
.2
.1
0
10
20
30
40
50
60
70
80
90
100
DWORSHAK CONTENT - % FULL

Figure 9 - Y1 (+) & F (*)


SYSTEM CONTENT - % FULL
100
90
80
70
60
50
40
30
20
10
0
.1
.2
.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.8
99.9
PERCENT UNDER
NORMAL PROBABILITY PLOT

resultant system refill in two 40-year studies, F and Y1. In contrast to the V Study which had flow controls at Priest Rapids and Lower Granite, the Y1 Study had a flow control only at McNary. Both studies based their fishery flow reductions on volume runoff as measured at The Dalles. It is felt that system refill for the fishery recommendations contained in this document will more closely approximate the Y1 Study because Snake River flows will be tied to volume runoff on the Snake, not the combined systems. Definitive statements on the impacts of the fishery flow recommendations on reservoir refill cannot be made at this time. These are not refill studies and great care should be used in making conclusions about these figures.

The impact on firm load or thermal decrement cannot be stated accurately at this time. Figure 1 shows that for the case Study "F," it was assumed there was no firm load reduction. The "M" Study, or full fish flows every year, resulted in a firm load reduction of 3,750 mw in worst-case conditions, i.e. dry years including all of the critical period and over a 4 - 5-month period. In contrast, the "V" Study, which allows extreme fish flow reductions in dry years (less than 82.5 MAF January-July as measured at The Dalles and poor refill probabilities on the Snake system, causes only a 180 mw load reduction based upon the Corps of Engineers model results. The Y1 Study, which modeled flow reductions but did not include flow increases, and used 1995 loads and resources, shows a thermal decrement of 780 mw.

Areas for Further Consideration

The studies described above are only initial efforts, and further studies are indicated:

1. The recommended minimum fishery flows with reductions and increases, based upon volume runoff at Priest Rapids and Lower Granite needs to be modeled and the results analyzed. It is anticipated that this will be done immediately upon completion of this document and a supplemental report will be submitted as soon as possible to the Council.

2. The availability of unallocated storage in the upper Snake needs to be investigated. The Bureau of Reclamation has suggested that this is

available for purchase. Reauthorization of the Bureau of Reclamation projects which have unallocated storage should be reviewed for feasibility for improving fishery flows along with the other existing benefits.

3. The use of Canadian storage to help augment flows for fish should be an item of consideration, not only from a technical point but legal as well. Canada benefits greatly from fish production in the Columbia River and should be made aware of any increased fishery production through utilization of some of their storage.

4. Mandatory flood control requirements imposed by the Corps of Engineers should have a thorough review. These constraints somewhat suppress the amount of storage that can be reserved for fish flows late in the spring. A thorough update is required in light of recent storage projects. Relaxing some flood control requirements, especially in the Snake system will provide more water for other benefits such as power and fish flows.

5. There will be a continuing need for an economical scheme that will dispose of the spring time over-generation created by increased flow requirements for fish.

6. A thorough review of irrigation depletion projections should be made in light of increased pumping costs.

7. Study of the possibility of increasing the frequency of optimum flows.

Conclusions: The fishery agencies involved in producing the recommended minimum fishery flows using the Corps of Engineers and BPA models have produced many flow/power scenarios in a short amount of time. Much has been learned about the model and the Columbia River system, but there is much more to be understood which will require more time and effort. Areas mentioned in the report such as irrigation depletion, thermal maintenance shifts, use of separate forecasts for the Snake system, and reservoir regulation (e.g. when and where should draft/refill occur to maximize the storage in the system) require significantly more attention in the model.

Models have limitations and should be used with care. Interpretation of results without an understanding of their formulation can easily result in exaggerated or erroneous conclusion. It is expected that the Regional Power Council and Council staff will study the model and its limitations prior to drawing conclusions about such things as study output and economic impacts.

These recommendations represent an initial attempt by the fishery agencies and tribes to accommodate all interests in the Columbia system. There can be no questions that further work is needed, as noted above, but the basic framework has been established in these recommendations. Overall impacts to the power system from fish flows appear to be minimal. Although the impact on the refill of reservoirs could be significant for Dworshak and Hungry Horse reservoirs, with the continued support from the Corps of Engineers and Bonneville Power Administration, these problems can be resolved.

Recommendation: (1) That the Power Planning Council include in its Fish and Wildlife Program the adoption of the flow regime and support the areas of further study described above to allow management of the Columbia River System so minimum flows are achieved or exceeded in all years and Indian treaty objectives can be fully met. (2) That the Power Planning Council include in its Fish and Wildlife Program support for continuation of the Instream Flow workgroup with the addition of members from the Council's staff.

APPENDIX A-A

An economic analysis of Study "V" is continued at the end of this document. A similar economic analysis will be made on the study conducted which analizes the near term fishery flow recommendations stipulated in this Task 1.1.1. Both of these analyses will be presented to the council as soon as possible.

APPENDIX B-B

This appendix is a compendium of the studies made during the course of developing these recommendations. It can be provided upon request.

LITERATURE CITED

1. HENGESTEG, PETER O.
1981. Unpublished summary of Studies on Recommended Minimum Fishery Flow Requiremends, U.S. Army Corps of Enginers, North Pacific Division, Portland, Oregon.

2. COLUMBIA RIVER FISHERIES COUNCIL
1979. Rationale for Instream Flow for Fisheries in the Columbia and Snake Rivers, Portland, Oregon.

3. STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY
1980. Columbia River Instream Resource Protection Program, Olympia, Washington.

Task 1.1.2: Monitor and evauate the flow regime resulting from criteria adopted by the Power Planning Council to determine its impact on juvenile salmon travel time, survival, and overall success of migration.

Introduction: Annual monitoring of the juvenile salmonid migrations at key dams on the Columbia River system provides vital information relative to the timing, magnitude, survival, and migrational behavior of the various stocks. Such information is essential to the continued review of the river flow criteria necessary to provide optimum protection for non-transported smolts throughout the system. Continuous monitoring is also necessary to define the specific projects and/or areas of the river that are adversely impacting migrating juveniles. In addition, the effectiveness of mass transportation and other experimental techniques attempting to enhance smolt passage survival all require an in-place monitoring system to evaluate their effectiveness.

Current Status: With Corps of Engineers funding, the National Marine Fisheries Service has monitored the survival, migration rates, and timing of salmon and steelhead smolts in the Salmon and Columbia rivers since 1966. The data collected have formed the basis for most flow/survival information (Raymond 1968, 1979; Sims and Ossiander 1981) available at this time and has provided a year-by-year appraisal of the relative success or failure of the salmonid migrations in the Snake River system (Raymond et al. 1974, 1975; Sims et al. 1976, 1977, 1978, 1981; Raymond and Sims 1980).

Monitoring should continue to provide statistically evaluated information relative to smolt survival, travel time, and migration rates and timing. Analysis of this information in relation to existing flow regimes will provide data necessary to evaluate and upgrade instream flow recommendation.

Specifically the monitoring must evaluate the relationship of spring and summer flow guantities to smolt survival. Additionally the effects of providing flow recommendations on a daily average vs weekly average basis must be evaluated in relation to smolt survival.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program monitoring of smolt outmigration down the Snake and Columbia Rivers to evaluate the effectiveness of specific spring and summer flows, and daily vs weekly average flows on smolt passage and survival.

Subobjective 1.2: Provide flow regimes below hydroelectric projects located on tributary streams throughout the juvenile downstream migration period.

Introduction: Juvenile downstream migration occurs throughout the entire year. Natural or artificially produced freshets tend to induce the migratory urge of juveniles as well as improve their safe passage and survival through the tributary (Cramer and Martin, 1978).

It is reasonable to establish and expect to receive minimum fishery flows in tributaries on which hydroelectric projects are located throughout the year. It is unreasonable to expect the same for flushing flows throughout the entire year. In an effort to take fullest advantage of the limited water available, flushing flows must be planned for greatest juvenile outmigration.

The period of greatest juvenile passage occurs in the spring, normally peaking between April 1 and June 15. The precise peak of greatest outmigration will vary within a relatively narrow band depending on a variety of factors, i.e. species, strain, location of tributary, climate, etc. The flow regimes established in this section of the plan are intended to ensure adequate spawning and rearing flows as well as providing safe outmigration of juveniles using the minimum quantity of water.

Indepth information on flow regimes is not known for each tributary in the basin. It will be necessary in the future to develop this criteria to ensure wisest use of water for the fishery resource and for power.

Task 1.2.1: Willamette River and Tributaries

The Corps of Engineers has constructed a 13-dam multi-purpose water storage complex in the Willamette Basin. Those projects which include Detroit, Green Peter, Lookout Point, and Cougar reservoirs are listed in Table 1. Associated minimum flows for each project are also listed. These flows were mandated by Congress in House Document 531, Eighty-First Congress, Second Session, which authorized a modified Willamette plan in 1950. While no fisheries research has been conducted on the adequacy of these flows for the downstream migration of juvenile anadromous salmonids, observations indicate that they are generally adequate to provide a safe and timely migration route.

In some instances, however, the minimum flows are inadequate for migrations of adult salmonids and for sport fishing. These concerns will be addressed under Task 2.1.3 later in this report.

Recommendation: That the Power Planning Council include in its Fish and Wildlife program minimum flows for the purpose of juvenile outmigration outlined in Table 1 and substantiated in H.D. 531 to assure the long-term productivity of the Willamette Basin fisheries.

PERTINENT RESERVOIR DATA

WILLAMETTE RIVER BASIN RESERVOIRS

SEPTEMBER 1972

RESERVOIR	Normal Max Release	RELEASE IN C.F.S. DURING HIGH FLOW PERIODS: Minimum Release	Max Rate of Increase: Normal Per Hr.	Max Rate of Increase: Limit Max Per Hr.	DURING LOW FLOW PERIOD: Minimum Release	Max Rate of Increase: Normal Per Hr.	Max Rate of Increase: Limit Max Per Hr.	Limit of Reduction in Outflow Per Half Hr.	FIRM POWER RELEASE	OUTLET WORKS	SPILLWAY CREST ELEVATION (FT., M.S.L.)	NO. OF UNITS	RATING PER UNIT
FALL CREEK	4500	50	50 – 1000 = 300 1000 – 4000 = 500	800	May-June 150 (FISH) Jul-Apr 30	200	200	4000	–	2 Outlets 2 Spwy	791.6	–	–
COTTAGE GROVE	3000	50	350	500	75 Feb-June 50 July-Oct	100	100	3000	–	3 Outlets Open Spwy	791.0	–	–
DORENA	5000	100	100 – 2000 = 500 2000 – 5000 = 750	1000	190 Feb-June 100 July-Oct	200	200	5000	–	5 Outlets Open Spwy	835.0	–	–
FERN RIDGE	4000	50	750	1000	50 Feb-June 30 June-Nov	200	200	4000	–	4 Outlets 1 Sluice 6 Spwy	358.5	–	–
BLUE RIVER	3700	50	50 – 100 = 50 PER HALF HR. 100 – 500 = 100 " " " 500 – 1000 = 200 " " " 1000 – 2000 = 400 " " " 2000 – 3700 = 600 " " "		50	50 – 100 = 50 PER HALF HR 100 – 500 = 100 " " " 500 – 1000 = 200 " " " 1000 – 2000 = 400 " " " 2000 – 3700 = 600 " " "		30% (Below 200 CFS 30% per 15 Min.)	–	2 Outlets 2 Spwy	1321.0	–	–
HILLS CREEK	8000	100	100 – 1000 = 300 1000 – 5000 = 500 500 – 8000 = 800	1200	100	300	300	4000	800	2 Outlets 3 Spwy	1495.5	2	15 MW 800 CFS
LOOKOUT POINT	15,000	500	500 – 1000 = 500 1000 – 4000 = 1000 4000–15000 = 1500	2500	1200 Feb-June 1000 July-Nov	500 – 4000 = 300 4000 – 15000 = 500	500	30%	2800	4 Outlets 5 Spwy	887.5	3	40 MW 2500 CFS
DEXTER										7 Spwy	660.0	1	15 MW 400 CFS
COUGAR	6500	100	100 – 500 = 250 500 – 6500 = 500	750	300 Feb-June 200 July-Nov	200	200	3000	750	2 Outlets 2 Spwy	1656.75	2	12.5 MW 450 CFS
GREEN PETER	11,000	50	–	–	50	–	–	–	2100	2 Outlets 2 Spwy	968.7	2	40 MW 2000 CFS
FOSTER	18,000	Inflow up to 10,000	500 – 1000 = 500 1000 – 3000 = 1000 3000–18000 = 1500	2500	800 FEB-APR 750 MAY 600 JUNE 400 JULY-NOV	300	300	30%	2500	6 Spwy	596.79	2	10 MW 1600 CFS
DETROIT	17,000	100	100 – 1000 = 500 1000 – 3000 = 1000 3000–17000 = 1500	2000	1000 Feb-June 750 July-Nov	750 – 3000 = 200 3000 – 10000 = 500	500	30%	2000	4 Outlets 6 Spwy	1541.0	2	50 MW 2300 CFS
BIG CLIFF										3 Spwy	1161.5	1	18 MW 30

Task 1.2.2: Deschutes River

The Portland General Electric Company constructed Pelton and Round Butte dams on the Deschutes River in 1958 and 1964 respectively. The FERC license for these projects requires minimum flows of 3,500 cfs March - July and 3,000 cfs for the remainder of the year. While no research has been conducted on the effects of these flow criteria, observations indicate that they are generally adequate for downstream migration of anadromous smolts.

There is evidence, however, that controlled flows, i.e., reduced peaks, have had an adverse impact on the quality and quantity of spawning gravels in the Deschutes below Pelton Dam. This problem will be addressed under Task 3.2.2 later in this report.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the above minimum flows included in the FERC license for Round Butte and Pelton dams for the purpose of juvenile outmigration, to assure the long-term productivity of the Deschutes River fisheries.

Task 1.2.3: Cowlitz River

The Cowlitz River is presently dammed by two larged high-head hydroelectric facilities that are owned and operated by Tacoma City Light. These projects include Mayfield Dam, located at R.M. 52.0 and Mossyrock Dam located at R.M. 62.5. Above R.M. 52, downstream passage conditions are adversely impacted by the two dams and reservoirs. Studies by the Washington Department of Fisheries indicate that migrating salmon, especially chinook salmon, are significantly delayed in each of the two reservoirs (Thompson, 1965, 1969). Attempts to collect fish at the head end of Mossyrock Pool by using floating net pens was not found to be a feasible way to collect migrants (Erho, 1967, Hager, et al., 1970).

For the above reasons, compensation for losses above Mayfield Dam are in the form of hatchery production, and occur at two large stations located on the lower Cowlitz River. These hatchery facilities produce spring and fall chinook, Coho, steelhead, rainbow, and sea-run cutthroat trout. Natural populations of each of these species, as well as chum salmon, exist in the lower 50 miles of the Cowlitz River.

The Department of Fisheries has recently contracted with Tacoma City Light to assess the adequacy of the Cowlitz Salmon Hatchery in meeting its current escapement compensation responsibilities of 25,000 coho, 17,300 spring chinook, and 8,300 fall chinook. This assessment is ongoing and is scheduled for completion in early 1982. The results of this analysis will be used to adjust hatchery production in order for the compensation levels to be achieved.

Juvenile fish passage conditions below Mayfield Dam are considered adequate. A Federal Energy Regulatory Commission license minimum flow requirement of 2,000 cfs at Mayfield Dam is sufficient to move smolts downstream in a timely manner. However, when large numbers of hatchery smolts are released, a stablilized flow is requested from Mayfield Dam to help prevent stranding and potholing of smolts. These stabilized flow periods

normally range between two to seven days. Tacoma City Light has been receptive to these requests and have provided these and other flow adjustments, for protecting juvenile migrants, when possible. Details of a stabilized flow regime and its potential benefits are outlined in Task 3.2.3.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program a 2,000 cfs minimum flow level below Mayfield Dam to ensure that fisheries protection is provided in the future.

Task 1.2.4: North Fork Lewis River

Anadromous fish runs only exist in the North Fork Lewis River and mainstem below R.M. 19.5 due to a three-dam complex located on the North Fork. All three hydroelectric dams are owned and operated by Pacific Power and Light (PP&L) with Merwin Dam at R.M. 19.5, controlling flows to the lower North Fork and mainstem Lewis River. Wild runs of spring and fall chinook, coho, and chum salmon, steelhead and sea-run cutthroat trout exist in the lower North Fork. Compensation hatchery production at two stations (Lewis River and Speelyai), consists of spring and fall chinook and coho. Some pen rearing of steelhead has taken place in Merwin Reservoir in recent years. All fish produced at these hatcheries are released in the lower North Fork Lewis.

The Federal Energy Regulatory Commission license for the Merwin Project requires a minimum flow of only 760 cfs. This was based on the historical low flow period and, based on observations, is inadequate to meet most fish needs.

The 760 cfs is not sufficient to promote good downstream movement of smolt populations, especially large hatchery plants. These fish apparently reside in the river if sufficient flow is not available to aid in their downstream migration.

The Department of Fisheries has requested of PP&L that 1,500 cfs be established as a realistic year-round minimum flow. This request was made on the basis of observed fisheries behavior at various low flow levels for many years. To date, PP&L has not adopted the 1,500 recommendation but negotiations on this and other flow problems are continuing. The Merwin Project's license expired in December 1979 and it is the intention of the Washington Department of Fisheries that 1,500 cfs be included as a new license requirement. However, the Washington Department of Game could have reservations relative to the 1,500 cfs minimum flow if it would jeopardize their resident trout fishery in the reservoirs.

The Department of Fisheries has also made several requests of PP&L to provide adequate flows when large hatchery plants are made. Most often these requests are not honored. PP&L apparently is reluctant to alter their total system operation schedule to accommodate Washington Department of Fisheries requests. This problem must be corrected as hatchery plants can be significantly impacted.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program a year-round minimum flow of 1,500 cfs for the Merwin Project.

Task 1.2.5: Clearwater River

The Corps of Engineers operates Dworshak Reservoir on the North Fork Clearwater River. The Reservoir Regulation Manual for the project specifies a 1,000 cfs minimum flow. Flow releases from Dworshak should, however, generally be at or near the present full powerhouse capacity of 10,000 cfs on an average daily basis from April 15 to June 15. These flows would assist in moving hatchery smolts out of the North Fork Clearwater River and aid the movement of both wild and hatchery smolts down the main Clearwater and Snake rivers.

Releases from Dworshak Reservoir are critical to attaining necessary minimum spring flows in the Snake and Columbia Rivers for the effective outmigration of anadromous salmonids (see Task 1.1.1). During the period April 15 - June 15 the proposed fishery flow regime would generally guide flows for Dworshak and during periods of high natural flow and excessive spilling at Snake and Columbia River projects, flows from Dworshak may be reduced. In years of low natural runoff, Dworshak should be called upon to provide flows greater than 10,000 cfs for certain periods during the smolt outmigration to assist in migration in the Snake and Columbia rivers. Since spilled water can create nitrogen supersaturation, spills greater than about 10,000 cfs should be monitored for nitrogen supersaturation. Fishery regulation of Dworshak Reservoir during the spring outmigration will therefore be guided by flow needs throughout the Columbia Basin. A minimum flow guide from April 15 - June 15 should be 8,000 - 10,000 cfs.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the adoption of an April 15 - June 15 minimum flow guide of 8,000 - 10,000 cfs at Dworshak Reservoir with variations to meet downstream fishery needs.

Task 1.2.6: Yakima River

Three hydroelectric projects on the Yakima system can be addressed under this task: Prosser Dam (R.M. 47) and Roza Dam (R.M. 128) on the mainstem Yakima, and Naches Dam (R.M. 4) on the Naches River, a tributary to the mainstem.

Spring and fall chinook and coho salmon and steelhead trout utilize the system. Spring chinook are the most abundant species. The major period of juvenile outmigration occurs from April thorugh June. At Prosser Dam, the peak of spring chinook outmigration normally occurs between mid-April and mid-May (Major and Mighell, 1969).

Mongillo and Faulconer (1980) have identified minimum flows necessary at the power dams to flush outmigrants from the system:

Naches Diversion Dam	-	1,100
Roza Diversion Dam	-	4,900
Prosser Diversion Dam	-	11,200

Washington Department of Fisheries wishes to examine the flow at Prosser further before concurring in its adoption.

No optimum flows have been established.

Recommendation: That the Power Planning Council adopt in its Fish and Wildlife Program the minimum flows as set forth in Mongillo and Faulconer (1980). Results can be monitored to determine if changes are required. Optimum flows shall then be identified.

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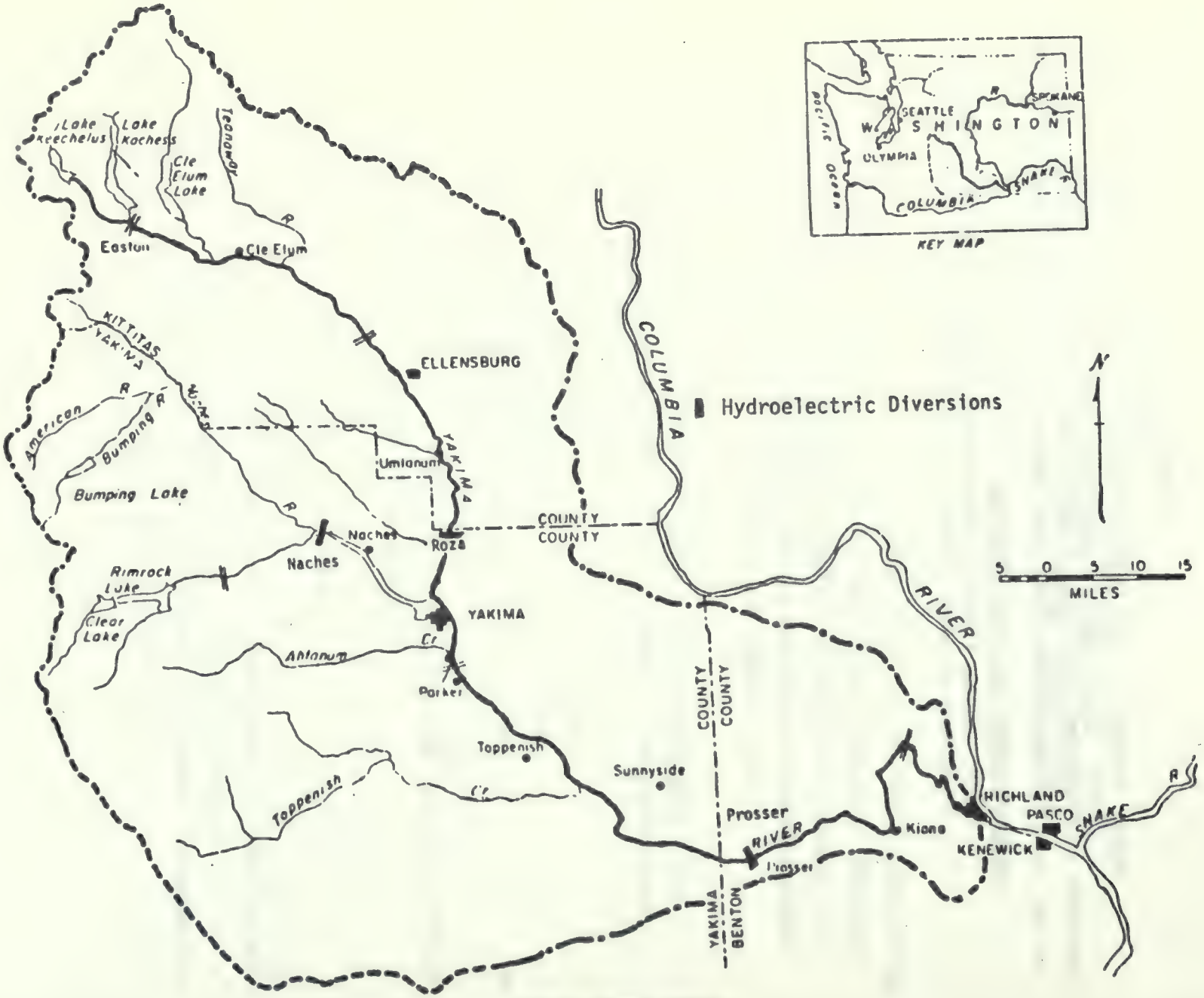

Yakima River Basin

Task 1.2.7: Hood River

Pacific Power and Light Company owns and operates Powerdale Dam, FERC Project No. 2659 on Hood River. Following studies with the fishery agencies the following minimum folws were developed and submitted to FERC by letter of February 10, 1971 from George Beard to Gordon Grant.

Month	Flow (CFS)
February 1 - April 30	270
May 1 - June 30	170
July	130
August 1 - November 30	100
December - January	170

Since adoption of these flows, the downstream migration of smolts is believed to be adequate.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the above minimum flows for the purpose of downstream juvenile migration to assure the long-term productivity of Hood River fisheries.

Subobjective 1.3: Develop or improve juvenile fish bypass facilites and operations at the lower thirteen Columbia and Snake River dams.

The development of facilities that intercept and bypass juvenile salmon and steelhead around hydroelectric dams is based on several studies, demonstrating that turbines do kill a percentage of the fish that pass through them. Kaplan turbines are used in the low-head, mainstem dams on the Columbia and Snake Rivers. Bell et al. (1967), who analyzed the available literature, described the design and operating criteria that influences the magnitude of mortality caused by a given turbine. These include wicket gate setting, discharge, pressure differentials, turbulence, specific speed, and sigma (a ratio of head to depth turbines below tailwater). As the head on a plant increases, fish mortality was found to vary with turbine load, i.e., mortality is least at that load which produces the highest hydraulic efficiency (usually somewhere between minimum and maximum acceptable loads) and increases as the turbine load departs from that of highest efficiency.

Turbine mortality studies have been conducted on three low-head dams that contain Kaplan turbines on the Columbia and Snake rivers, McNary, Ice Harbor, and Lower Monumental. Schoeneman, et al. (1961) measured 9 to 13 percent mortality of the relatively small fall chinook fingerlings at McNary Dam. Long et al. (1968), using larger 1+ age coho fingerlings demonstrated that fish passing through turbines at Ice Harbor Dam suffered both direct (killed by the turbines) and indirect (killed by predators) losses. Losses due to predators occurred in the slack water areas of the immedate tailrace. Only a portion of the survivors of turbine passage entered these slack water zones. The reason these predation losses are described as indirectly caused by the turbine is because these fish would not have entered the slack water zones voluntarily. They entered the slack water only because passage through the turbine placed them in that part of the turbine discharge that carried them there. Long, et al. demonstrated a total (direct and indirect) loss of 30 percent and estimated that direct loss fell between 10 to 20 percent.

In a subsequent year, Long, et al. (19) made a similar study at Lower Monumental Dam where indirect losses were at least minimal, probably non-existent, due to the virtual absence of predators in the tailrace. In these studies, the total loss of coho fingerlings was 19 percent. Presumably this loss was entirely due to the turbine. In both the Ice Harbor Dam and Lower Monumental Dam studies, the turbines were operated at the maximum load, about 115 percent of rated capacity. This indicates that some limitation is needed on the amount of overload that should be tolerated during downstream migrations.

Several studies also have been conducted in which the overall loss of fish was measured after passing through a series of dams. Raymond (1979) measured a loss of 95 percent of 1+ age chinook after passing through 5 dams in 1973. In that year, river discharge was too low under existing operating criteria to provide for spillway operation. Consequently, all the fish had to pass through turbines at each dam.

The powerhouse loss incurred at a single dam may be tolerable during a normal year. In the case of the Columbia and Snake rivers, however, upriver stocks on the Snake must traverse eight dams and those from the upper Columbia, nine dams. In some years of lower river discharge, all the fish were required to pass through the turbines of each dam. As shown in the following calculations, a loss of only 15 percent at each dam would result in an overall loss of __ percent for eight dams and __ percent for nine dams. These estimates are determined as follows:

$$P = (1 - i)^{(n)}$$

where P = The percent of the population remaining after passage through a dam

i = The precent loss in passing through a dam

n = Number of dams

Thus, for a loss of 15 percent at each of eight dams we find

$P = (1-0.15)^8 = 27$ percent and for nine dams,
$P = (1-0.15)^9 = 23$ percent

There is no doubt that turbines kill fish and that some means for protecting the resource must be devised. As a consequence, research on methods for guiding fish around turbines has been underway since at least 1930 (Yates, 1930. Since then, researchers have tried lights, sound electrictity, air bubble screens, hanging chains and nets, louvers, drum screens and horizontal screens that travel continously, and vertical screens that travel intermittently to remove debris. Millions of dollars have been expended on research and trial installations of all of these methods. Only louvers and screens have had sufficient success to warrant continued development. Each basic design has limitations regarding its application at specific sites, and, by 1959, no developed method was available that could protect the fingerlings at low-head dams.

By 1959 the problem of protecting fingerling salmon at low-head dams on the Columbia River had not been addressed by researchers by 1959. Research had shown that fingerling salmon were more or less distributed throughout the river with a tendency to concentrate near the surface. The width of the forebays and their 50 to 100-foot depth presented a significant impediment to devising a method of intercepting and guiding to safety a significant percentage of the migrating fish at each dam.

The solution lay in finding a location where the fish tended to concentrate, a location where a smaller fish-guiding device would suffice. Ivan Donaldson noted the occurrence of juvenile fish in intake gatewells in the U.S. Army Corps of Engineers Annual Report for 1950. In 1959, Long (1964) made the first measurements demonstrating that significant numbers of such fish volitionally entered turbine intake gatewells. In 1960 and 1961, Long (1968) measured the vertical distribution of fingerlings in turbine intakes which verified that fingerlings concentrated near the ceilings of turbine intakes and conceptualized (1961) the present system new in general use. This system called for guiding fish from intakes into gatewells, then providing the fish with egress from gatewells into the ice and trash slucie which would transport the fish around the dam (Figure 1). This system also

took advantage of the way the dams were constructed, saving significant expense.

before a full-scale bypass effort could be mounted. First, there was no guiding device work in turbine intakes. Second, there were two other bypass approaches that had not been sufficiently investigated. From 1961 through 1966, the research approach to protecting fingerlings at low-head dams took three directions (1) making turbines safe, (2) controlling turbine loads during peak periods of fish passage to minimize turbine mortality, and (3) bypassing the fish. The problem of selecting the best approach was resolved in 1968, when turbine mortality studies at Ice Harbor Dam showed that even 100 percent survival of smolts passing through turbines was not sufficient where large numbers of predators such as squawfish are present in the tailrace of dams. As cited earlier, Long (1968) showed that predators alone could reduce survival of turbine-passed fish by 10 percent. As a consequence, research was concentrated on methods for bypassing the fish around dams and methods for increasing survival of fish passing through turbines was not subject to further investibation.

The fingerling bypass system originally conceived in 1961 was selected for development. The method not only can bypass fish around a dam, but also lends itself to the collection of fish for transport around the dam. The method also takes advantage of the existing dam structures, eliminating many new-construction costs that otherwise would be necessary. For example, the turbine intakes are already equipped with trash racks, locating a traveling screen in the intakes eliminates the need for providing additional protection from debris.

By 1969, hydraulic model studies and field trials of new submersible traveling screen (STS) for guiding fish out of turbine intakes were completed (Long, 1969; Long et al, 1970). Installation of the STS at federal dams has followed gradually. By 1972, Little Goose Dam was equipped with a complete bypass system which included only three STS. By 1975, however, all 18 intakes were equipped with STS. Since that time, Lower Granite Dam and McNary Dam have also been equipped. By 1983, the Bonneville 1st and 2nd

powerhouses and by 1985 John Day Dam powerhouse will be fully equipped with this fingerling bypass system.

Every year since 1973, studies have been conducted to define deficiencies and improve the STS system. Each new dam presents at least a few problems that are specific. Modifications of the basic system are reqwuired to alleviate these problems. Of course, each modification must be evaluated after installation.

By 1985, 24 years will have passed since the present fish bypass was conceptualized. Clearly, the development of alternative methods will not be accomplished overnight.

Over the years alternative bypass systems have been fully considered. One promising approach, initiated in 1969 at Bonneville Dam, is referred to as a skimmer. The skimmer attempts to attract fish to a special surface flow created by opening one or more gates to the ice and trash sluice. The objective is to cause fish to enter the sluice for transport to the tailrace rather than pass through the intakes and turbines.

This method was recently evaluated at Bonneville Dam by comparing its efficiency with the STS-bypass system. Efficiency of the skimmer ranged from 2.5 percent for fall chinook salmon to as as high as 58.9 percent for steelhead. The STS-bypass method, however, captured from 71.5 percent to 81.7 percent of all species (Krcma et al, 1981). As a consequency, the fishery agencies recommended the STS-bypass system be used at Bonneville.

The ice sluice-skimmer method is more successful at The Dalles Dam where efficiencies of 40 to 80 percent have been measured (Nichols, 1979). Orientation of the powerhouse parallel to the river flow causes the fish to concentrate at the downstream end of the powerhouse (Long, 1968). Opening ice sluice gates in this region are therefore more effective.

Of the two methods, the STS-bypass system is the most effective and has broader application than the ice-sluice skimmer. The skimmer apparently approaches effectiveness only in special cases.

Until an effective bypass is installed at each dam, losses can be reduced by spilling. The use of adequate spill and turbine manipulation as a means to minimize losses of juvenile salmonids at Columbia River hydroelectric facilities is accepted as an interim alternative to smolt bypass systems (CRFC, 1979). The Columbia River Fisheries Council has recommended spills and turbine manipulation as an interim measure at those projects lacking efficient smolt bypass systems. Research has shown that mortality rates are lower among juvenile salmonids passing over spillways than among those forced to pass through turbines (Schoeneman, et al., 1961). The use of spill and turbine manipulation at John Day was found to reduce project mortality of 12 percent as compared to 27 percent with low levels of spill and no turbine manipulation (unpub. report, Howard Raymond, NMFS).

The value of spill is a critical facit in juvenile passage. Significant amonts of spill will be required to significantly improve passage conditions pending installation of bypass systems. Hydroacoustic monitoring studies conducted at Priest Rapids Dam examined fish distribution and passage through the project. Spillway and powerhouse passage was studied under normal plant operating conditions. Within the minimal spill levels which were tested the study indicated that with normal powerhouse operation fish are passed in spill roughly in proportion to the volume of water spilled (Carlson, Acker, Gaudet, 1980).

The basic system now in general use at Corps of Engineers dams is depicted in Figure 1. Fish entering turbine intakes are intercepted by a submersible traveling screen (STS) that diverst fish up into the associated intake gatewell. A vertical barrier screen (VBS) prevents the guided fish from escaping back into the intake downstream of the STS. A submerged orifice in each gatewell provides for passage of the fish from the gatewells to a conduit or flume that transports the fish to the tailrace.

This general scheme is designed to intercept 70 percent or more of the fingerlings entering turbine intakes based on the tendency of fingerlings to concentrate near intake ceilings (Long, 1969). This particular fingerling protection system also is flexible in that fish can be merely bypassed to the

tailrace, or the fish can be readily removed from the bypass and placed aboard trucks and barges for transport around the remaining dams.

As expected with any system, careful design, installation, and operation of all system elements is required in order to ensure that intercepted fish are given maximum security. The STS must be set at the proper angle (Park et al., 1979) and the traveling screen must be continuously in operation. Failure of the screen to rotate causes lethal impingement of the fish (pers. comm. Richard F. Krcma, NMFS, Pasco Biological Field Station, Pasco Wash.). Orientation of the terminal end of the STS in the opening to the gatewell also is critical to the fish guiding efficiency (FGE) of the screen.

The volitional passage of fish through orifices was a problem at several dams until Krcma, et al. (1978) defined the proper design and operating criteria in order to achieve satisfactory fish passage efficiencies (FPE). Even so, routine application of this knowledge at other dams requires careful evaluation. In 1981, for example, poor FPE was discovered at McNary Dam (Swan, et al., 1981). This problem will be addressed in the field season of 1982.

The flume or conduit used to transport the fish must be carefully sized to (1) carry the flow from all orifices and (2) have sufficient water velocities to ensure that fish do not delay and accumulate within the flume.

Where bypassed fish are to be released back into the river (rather than collected for transport) the release location must be carefully selected to avoid predation.

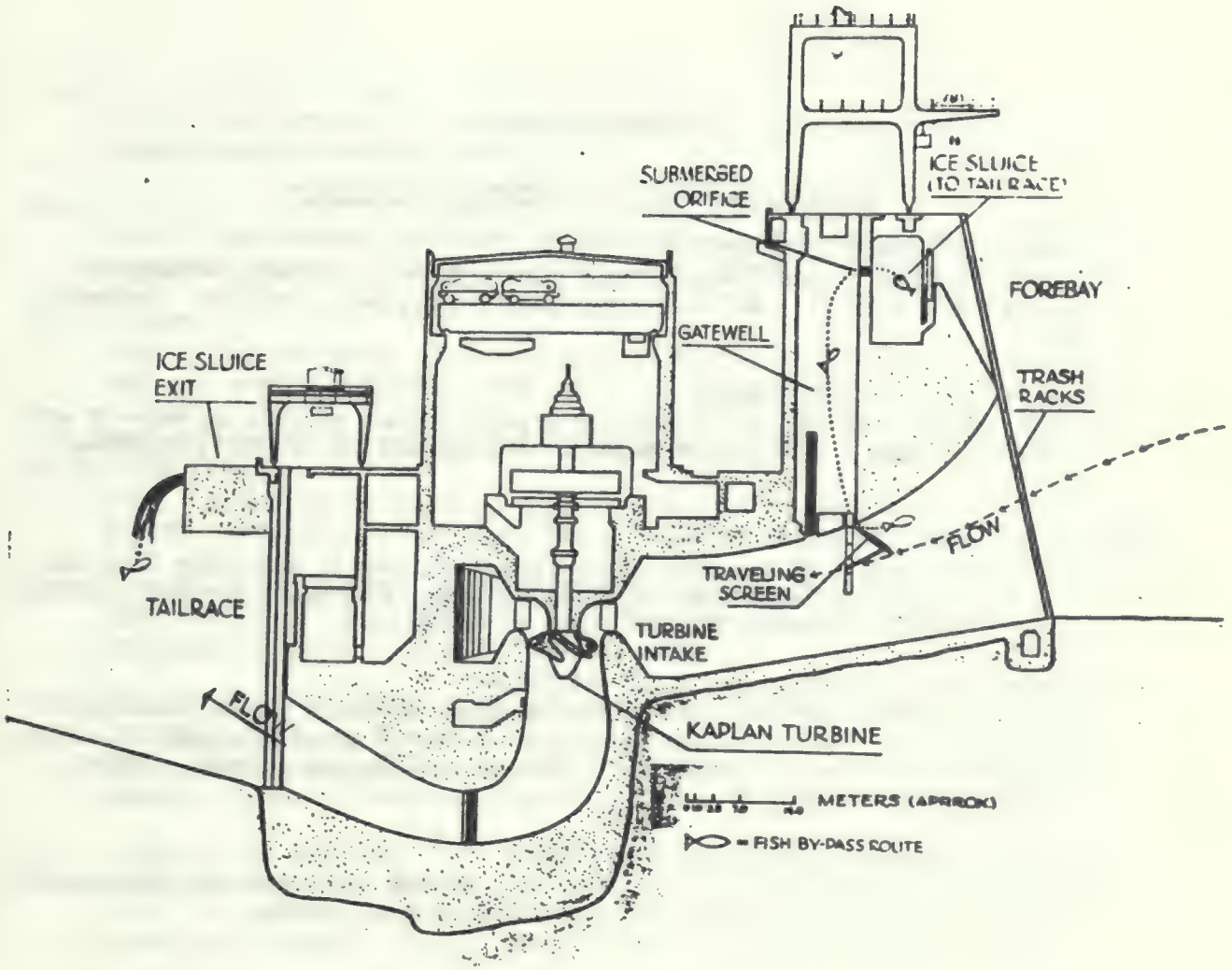

Figure 1.--Section of a typical turbine showing fish bypass route around dam.

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Task 1.3.1: Complete installation of juvenile bypass systems at Bonneville 1st and 2nd powerhouses.

Bonneville Dam is a run-of-the-river hydroelectric project with minimal storage capability operated by the Corps of Engineers. The project consists of three structures on separate channels divided by islands. A second powerhouse is still under construction and will be completed in 1982, approximately doubling the generating capacity of the original powerhouse and spillway which were placed in service in 1938. The separation of the two powerhouses requires two complete juvenile bypass systems. Due to the location of several large hatchery facilities on Bonneville pool, a very large downstream migration of hatchery fall chinook passes this project.

Bonneville Dam was the site of early studies of turbine mortality and juvenile fish distribution and timing in the 1940's and 1950's. The first recorded observations of juvenile fish accumulating in turbine intake gatewells were made here. The concept of passing fish out of a turbine intake through a submerged orifice port was first tested here in 1962. Use of the ice and trash sluiceway for juvenile passage was first studied here by Oregon Department of Fish and Wildlife in 1969. A comprehensive series of studies was initiated at Bonneville in 1975 by the Corps of Engineers and National Marine Fisheries Service to develop juvenile protection and passage facilities for the existing project and the planned new powerhouse. Model, laboratory, and field studies were carried out to evaluate the feasibility and effectiveness of alternative designs. Prototype tests of various orifice and intake deflector configurations were carried out at Bonneville and McNary Dams to simulate

conditions in the new powerhouse as well as the existing powerhouse. These studies identified the increased effectiveness of larger 12-inch gatewell orifices. Comparison studies were also conducted of the effectiveness of turbine intake collection and surface skim collection in the existing ice and trash sluiceway. These studies resulted in a recommendation by fishery agencies that intake traveling screens be installed at Bonneville 1st and 2nd powerhouses with gatewell orifices and gravity flow conduits to tailwater.

The second powerhouse was constructed with 12-inch gatewell orifices and an open flow collection channel. Fish are released through a conduit which exits through a pier on the bottom of the river downstream of the north end of the new powerhouse. Submersible traveling screens (STS) which intercept approximately the upper third of intake flow are being installed in the new powerhouse as turbine generator units are completed. Vertical barrier screens are used in the intake gatewells.

Similar STS are planned for installation at Bonneville first powerhouse in 1982 and 1983. Construction of 12-inch gatewell orifices, a separate collection channel within the ice and trash sluice, and a conduit to tailwater releasing downstream along the Bradford Island side of the channel are to be completed by spring 1983.

An evaluation of existing and planned bypass facilities at the two powerhouses is recommended for 1982 and 1983 with the principal objective of identifying needed structural and operational improvements. Correction of deficiencies and final evaluation of bypass operation would then be completed in 1984.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the construction of submersible traveling screens and appropriate bypasses in the two Bonneville Dam powerhouses by the Corps of Engineers and their evaluation and modification if necessary.

Task 1.3.2: Install juvenile bypass at The Dalles Dam

Current Status: The ice and trash sluiceway at The Dalles Dam is in use as a juvenile salmonid bypass system. The sluiceway is a large rectangular channel wich extends along the forebay side of the powerhouse immediately above the penstocks (turbine intakes). The forebay side of the sluiceway is composed of 70 adjustable gates which can be raised or lowered to allow water and trash to enter. Fish are skimmed off the surface of the forebay and transported through a channel to the tailrace below the dam, thus avoiding turbine associated mortalities.

The sluiceway has been in use as a bypass system since 1971. Since 1977 ongoing research by Oregon Department of Fish and Wildlife has continually improved sluiceway operation for downstream migrants. Key conclusions reached by the studies are as follows:

1. Sluiceway passage is highest with:

   A. Gates open only on the west (near Unit 1) or a combination of west and east rather than east only for yearlings.

   B. Gates open on the west or east for subyearlings.

   C. Maximum possible surface flow for both yealings and subyearlings.

D. Three adjacent gates open rather than two or four adjacent gates for yearling and subyearling fish.

2. Sluiceway operation can be reduced to 16 hours per day without significantly reducing the number of fish passing.

3. There is no direct or delayed mortality to fish using the sluiceway under suborifice flow (300cfs).

4. Sluiceway collection efficiency has been estimated between 40 percent and 85 percent primarily dependent upon estimation method used, which of the 70 forebay gates are opened, flow through gates opened, and time of year.

5. Fifteen million downstream migrants safely passed through the sluiceway from 1978 through 1981 (2.3-4.6 million per year).

The outmigration of juvenile salmonids has been found to occur from early April through August. Between 25 percent and 30 percent of the total outmigration has been found to occur between July 1 and mid-August when historically the sluiceway was not operated.

A sampling technique which reliably estimates fish passage through the sluiceway without resulting in significant mortality to captured fish is being refined. This technique can be used to monitor juvenile passage past the project on a continuing basis.

Needed Action and Research: The Dalles Dam sluiceway should be operated as a juvenile salmonid bypass system according to optimum operational criteria presently being developed by Oregon Department of Fish and Wildlife. Criteria for operation will be recommended in the project completion (Annual) report following analysis of data collected in 1981. Criteria will include the identification of sluicegates to be opened, the extent to which each gate should be opened, operation of the endgate, daily hours during which the sluiceway should be operated, and the annual season during which it should be operated. These criteria will aim at maximizing bypass efficiency while minimizing loss of water (potential) energy. Variables such as river flow conditions and power demand will be considered during criteria development.

The Dalles sluiceway is now operating at its full potential. However, a question still remains as to its actual collection efficiency. The estimates have ranged from 40 to 85 percent. A final study is needed to accurately estimate efficiency. If it is below 70 percent, concurrent use of some intake screens or deflectors may be required. If it is above 70 percent, no further protection for downstream migrants is necessary.

Refinement of the low-mortality sluiceway sampling technique now under study at The Dalles Dam should continue. Refinement of this sampling technique can be completed within 1 year. Once completed, the technique will provide a means of accurately assessing the size, time, and specific composition of the annual juvenile salmonid outmigration.

The sluiceway presently discharges into a slack water zone in the tailrace. As shown by Long et al. (1968), such zones often harbor large

numbers of predators such as squawfish. Research should be conducted to measure the loss of fish due to predation and, if significant, action taken to change the discharge to a more suitable location.

Results Expected from Research: Operation of The Dalles Dam sluiceway according to optimum criteria for bypassing juvenile salmonids or development of an alternative juvenile bypass system will result in a substantial reduction in passage-related mortality.

Development of a low mortality sluiceway sampling system, or "indexing" systems, will provide information useful for estimating population sizes, determining the magnitude of salmonid production, and relative survival of salmonids from various river segments, monitoring the timing of outmigrations of various hatchery and wild stocks, and determining recovery rates of marked fish from other projects.

Scope of Work: Detailed criteria for optimum operation of The Dalles Dam sluiceway as a juvenile salmonid bypass system are currently being developed by Oregon Department of Fish and Wildlife. Direct estimation of the bypass efficiency of the sluiceway and development of the low-mortality sluiceway sampling technique at The Dalles Dam should be continued. Development of the sampling technique involves straining a portion of the sluiceway flow; pumping captured fish and water out of the sluiceway and onto a work platform; condensing captured fish by passing the pumped water over a small, porous inclined plane; depositing the captured fish in a small holding tank for observation; and finally releasing the observed fish back into the sluiceway where they are bypassed around the dam.

Known numbers of marked fish should be released into the sluiceway to determine the proportion of sluiceway passage sampled (capture efficiency) by the sampling gear under varying levels of flow. Likewise, known numbers of marked fish should be released into the forebay to estimate sluiceway passage efficiency with the new sampling gear. The effect of external factors such as powerhouse loading and river flow rate on overall sluiceway efficiency should be determined.

Estimates of daily passage of juvenile salmonids past The Dalles Dam project should be determined from April 1 through September 30. Total sluiceway passage can be estimated by dividing hourly sluiceway catch by capture efficiency. Total project passage can then be estimated by dividing estimated sluiceway passage by sluiceway efficiency. Estimates of passasge through The Dalles Dam project can be compared with estimates of passage at McNary and John Day dams to determine the relative accuracy of indexing at The Dalles. The magnitude, timing, and survival of various hatchery and wild stocks passing through The Dalles Dam project should be determined.

Recommendation: That the Power Planning Council provide programmatic support for continued Corps of Engineers research at The Dalles Dam to determine bypass efficiency of the sluiceway and include in its Fish and Wildlife Program the continued full operation of the sluiceway as a bypass system and/or installation of turbine intake screening as a bypass system depending on results of the current reseach.

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Task 1.3.3: Install juvenile bypass system at John Day Dam

John Day Dam is a run-of-the-river hydroelectric project operated by the Corps of Engineers with some capability for flood control and power storage. The project was completed in 1968 and has generating capacity in excess of river flow except during extreme high runoff periods so that involuntary spill is infrequent and ldimited. The very large reservoir results in downstream migration delay and in some juveniles overwintering in the reservoir or residualism.

The powerhouse was constructed with submerged intake gatewell orifices and a closed conduit from the orifices to tailwater emptying off the downstream face of the powerhouse at the north end. Evaluation studies of this system were carried out by National Marine Fisheries Service between 1973 and 1977. The small 6-inch orifices and the limited conduit capacity were found to result in too little flow to adequately attract fish to move through the orifices. The outfall location in a slack water area was also found to result in very high predation loss to fish carried through the conduit. In 1977 and succeeding years, some voluntary spill has been provided by the Corps of Engineers in response to fishery agency requests to improve juvenile survival at this project. Engineering and design studies are presently being carried out by the Corps of Engineers to develop structural modifications permitting the use of 12-inch gatewell orifices with an increased water capacity in the bypass channel and conduit. This plan would involve relocating the outfall to a point downstream of the powerhouse with improved water flow condition. Field testing of portions of the proposed system were

carried out in 1981 at McNary Dam by National Marine Fisheries Service. Intake traveling screens of the same type as used at Bonneville and McNary Dams would be utilized in the John Day turbine intakes under the proposed plan. The schedule proposed by the Corps of Engineers calls for completion of structural modifications and traveling screen installation in 1985.

It is recommended that the Corps proceed with the implementation of this plan while maintaining close coordination with fishery agencies during the design process. The Corps of Engineers should plan to have three submerged traveling screens (STS) on site for prototype testing two years prior to final screen installation. With the current design and construction schedule this will require screening of one unit in 1983 for confirmation of STS design criteria for the John Day installation. Upon completion of bypass and STS installation, a complete evaluation of bypass operation will be required to determine operating criteria for the system and to identify needed structural and operational improvements. The last phase of this evaluation is to incorporate and evaluate such improvements. With the current schedule, this work can take place in 1985 through 1987.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the installation of intake traveling screens and a complete smolt bypass system at John Day Dam by the Corps of Engineers. Until such time as a complete bypass system is operational at John Day Dam, sufficient spill shall be provided to minimize juvenile salmonid losses during spring and summer migration periods.

Task 1.3.4: Improve juvenile bypass at McNary Dam

McNary Dam is a run-of-the-river hydroelectric dam operated by the Corps of Engineers and placed in service in 1953. The powerhouse has less hydraulic capacity than the downstream Corps of Engineers dams and water is routinely spilled in the spring and summer months. The large reservoir is responsible for downstream migration delays and residualization. The Hanford Reach of the Columbia River immediately upstream of McNary pool is the last major mainstem salmon spawning area in the system and rearing fall chinook juveniles pass McNary Dam in large numbers at pre-smolt sizes.

McNary Dam was the site of turbine mortality studies conducted by Washington Department of Fisheries in 1955 and 1956. Paul Fields and others at the University of Washington conducted passage tests in the McNary ice and trash sluiceway in 1960, 1961, and 1962, demonstrating that juvenile fish could be attracted through the sluice gates. In 1961, National Marine Fisheries Service studied vertical distribution of fish passing through the turbine intakes and demonstrated that most fish were concentrated near the intake ceiling as had previously been observed at The Dalles Dam (Long, 1969). In 1968, experimental orifices were drilled from turbine intake gatewells to the ice and trash sluiceway. These small orifices were operated for several years to prevent fish from accumulating in the gatewells. In 1978 through 1981 gatewell vertical barrier screens and submersible traveling screens (STS) were installed in McNary powerhouse and evaluation studies were conducted.

These tests included prototype evaluation of a two-part fixed intake screen constructed of stainless bar screen material. This alternative deflector design was found to produce comparable guidance to the STS but the problem of impingement of fall chinook fry was not resolved without reducing guidance efficiency.

The current bypass system in use at McNary Dam consists of turbine intake traveling screens to deflect fish into the emergency gatewell slot, vertical barrier screens to restrict fish to this gatewell slot and direct them toward the surface, 12-inch orifices to carry the fish into an open flume running the length of the powerhouse, and a 20-inch conduit to a separator facility which allows either trapping of fish for transportation or release to tailwater at the north end of the powerhouse.

A two-year study is recommended to identify deficiencies in operation of the bypass system. This would be followed by implementation and evaluation of needed structural and operational improvements.

A second powerhouse for McNary Dam has been proposed by the Corps of Engineers. The construction of this facility will require expansion of the bypass system with corresponding design and operational studies. Such plans have been included in the General Design Memorandum.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the Corps funded evaluation of the McNary Dam juvenile bypass system and necessary modification if studies indicate such a need.

Task 1.3.5: Install juvenile bypass at Priest Rapids Dam

Priest Rapids Dam is located at R.M. 397 on the Columbia River. The dam has operated since its construction in 1959 without any fish protection for juvenile downstream migrating salmon and steelhead. Priest Rapids is typical of Columbia River projects incorporating spillways and powerhouse with 10 vertical- shaft Kaplan turbine units. There are no collection and bypass facilities in place or planned for Priest Rapids. No progress has been made towards alleviating juvenile downstream migrant mortalities, a system mortality study of the five mid-Columbia projects including Priest Rapids showed substantial mortalities to juveniles occurred. Results from this test imply a per dam mortality rate of 17 to 25 percent (Chapman and McKenzie).

Some studies relating to juvenile migration have been conducted at Priest Rapids. Migration monitoring data have been collected by gatewell dipping at Priest Rapids. Through these studies horizontal distribution of smolts approaching the powerhouse is available. More recently, hydroacoustic monitoring has been utilized to determine vertical distribution and migration timing in conjunction with gatewell dipping. These hydroacoustic studies were conducted in conjunction with spill to assess the success of spill of small amounts of water relative to the river flow, to pass fish. Hydroacoustic study results have not been confirmed. Hydroacoustic methods do not provide information on species distribution.

The studies at Priest Rapids confirm results of earlier experimentation at similar Snake and Columbia river projects. The studies show that smolts pass

the project in the evenings and following the greatest flow, passing through the turbines. Spill was found to be generally successful in passing fish only to the proportion of river flow. Spill was found to pass fish generally in proportion to the volume of water spilled. Skim spill did not pass significant numbers of fish, probably due to the small volume spilled (Carlson, Acker, Gaudet).

Priest Rapids Dam does not include a bypass conduit or a collection system. Distribution studies to date indicate that turbine intake deflector orifice bypass system is feasible.

Confirmation of vertical smolt distribution data collected through hydroacoustic studies should be conducted. This will contribute to design of a collection system which will be effective for all species. Vertical fyke net tests would confirm hydroacoustic data and determine species distribution.

The similarity of design and structure of Priest Rapids Dam to other Columbia and Snake River projects with operational bypass systems allows immediate design testing of a prototype system.

The design, testing, and evaluation of a prototype bypass system is the first step towards installation of a permanent collection and bypass system. This relates to the primary goal of increasing survival of downstream migrants, by minimizing losses at hydroelectric projects. Prototype testing will produce final design and operational criteria for a permanent bypass facility.

Scope of Work (for 1982): A complete study plan to meet the following objective and produce required data should be developed.

I. Confirm findings of hydroacoustic data; determine species distribution in turbine intakes.

A. Fish a vertical fyke net in turbine intakes and correlate results with hydroacoustic monitoring and gatewell dipping.

II. Test a prototype collection and bypass system.

A. Adapt the present submerged traveling screen systems to Priest Rapids intakes. Test collection efficiency and operation at one turbine unit.

B. Explore feasible alternatives for a bypass conduit to tailwater from gatewells. Evaluate utility of present maintenance galleries for bypass conduits from gatewells. Evaluate construction of conduits to tailwater.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program research on prototype bypass systems and installation of a efficient and complete bypass system at Priest Rapids Dam. Until such time as a complete bypass system is operational at Priest Rapids Dam, sufficient spills shall be provided at Priest Rapids Dam to minimize juvenile salmonid losses during spring and summer migration periods.

Task 1.3.6: Install juvenile collection and bypass systems at Wanapum Dam

Wanapum Dam located at R.M. 415 has operated since 1963 without juvenile collection and bypass systems. A systems mortality study conducted during 1980 indicated that substantial mortalities of 17 - 25 percent per dam (Chapman and McKenzie) occur through the five-dam public utility district system on the mid-Columbia, including Wanapum Dam. Minimal spill has been provided at Wanapum to aid fish passage during the spring migration. Some migration monitoring utilizing gatewell dipping has been conducted. A study conducted at Wanapum to determine the effectiveness of 10 percent spill did not produce conclusive results (CH_2M Hill, 1980). Some preliminary hydroacoustic monitoring has taken place at Wanapum during 1981. This work addressed passage of fish over the Wanapum trash and ice sluiceway. Preliminary results indicate that fish passed over the sluiceway in a similar time pattern as they passed the powerhouse with primary passage during the evening (preliminary only, final report not complete). The possibility of utilizing the ice and trash sluiceway as a bypass has been considered. Past research at other projects has shown that successful use of ice and trash sluiceways for bypass systems is dependent on unique features of the project and the natural distribution of smolts in the forebay near the sluiceway. Results of hydroacoustic studies conducted during 1981 at Priest Rapids and Wanapum dams are not available.

Priest Rapids and Wanapum dams are similar in structural design of individual turbine intakes. Collection and bypass systems at these projects would also be of similar design and could be approached simultaneously.

A prototype collection and bypass system should be designed and tested in one unit at Wanapum Dam. This would result in basic information which would lead towards the installation and operation of permanent bypass facilities at Wanapum Dam. This would effectively accomplish a portion of the fishery goal to minimize juvenile downstream migrant mortalities at hydroelectric projects.

Scope of Work: A complete study plan to meet the following objectives and produce the required data should be developed.

I. Determine vertical and horizontal distribution of smolts approaching the project, by hydroacoustic monitoring and intake fyke net traps.

II. Test a prototype collection and bypass system.

A. Adapt the present submerged traveling screen intake deflector design operational at other projects to Wanapum Dam. Test collection efficiency and operation at one unit at Wanapum.

B. Explore feasible alternatives for a bypass conduit to tailwater from gatewells, evaluate the utility of modifying present maintenance galleries to bypass conduits. Evaluate the alternative of constructing a bypass conduit to tailwater.

C. If smolt distribution studies show that 70 to 80 percent of fish approaching the project are attracted to the ice and trash

sluiceway, conduct efficiency and operational tests of the sluiceway as a bypass system.

Recommendation: That the Power Planning Council include in its Fish and Wildlife program research on prototype bypass systems and the installation of a efficient complete bypass system at Wanapum Dam. Until such time as a complete bypass system is operational at Wanapum Dam, sufficient spill shall be provided to minimize juvenile salmonid losses during spring and summer migration period.

Task 1.3.7: Install juvenile bypass systems at Rock Island Dam

Rock Island Dam's first powerhouse has operated since 1933 without any juvenile migrant protection facilities. A second powerhouse was constructed in 1974 without downstream migrant facilities. A conduit from gatewells to tailwater was provided. As part of the Federal Energy Regualtory Commission proceedings regarding the second powerhouse, a pre- and post-flooding studies agreement was developed. This agreement included a turbine mortality study which was conducted at the second powerhouse during 1979. This study showed that mortalities through bulb turbines in the second powerhouse at Rock Island did not differ significantly from mortalities occurring in adjustable-blade, vertical-shaft Kaplan turbin units of other projects. A system mortality study conducted in 1980 through the five-dam public utility district system showed substantial mortalities of 17 - 25 percent per dam occurring through the system.

The pre- and post-flooding studies agreement include the installation and testing of a trap to evaluate intake gatewells as fish collectors and the bypass conduit in the second powerhouse. The trap was also intended to monitor the spring migration. This study including a mark recapture experiment was conducted during 1981, results are not yet available. Minimal spill has been provided at Rock Island to attempt to aid fish passage during the spring migration.

At the time the second powerhouse was designed the need for a collection and bypass system was recognized and discussed. After

construction and installation of the new bulb turbine units in the second powerhouse there was some indication by Chelan County Public Utility District that turbine intake deflectors would have to be specially designed to prevent intake velocity distribution problems. An alternative to present intake collection systems to avoid this problem at Rock Island is a combination of a small gatewell deflector and a trash rack guiding device. Hydraulic modeling of a small gatewell deflector should be conducted to evaluate design and size.

A trash rack guiding device, such as a bar screen would serve to concentrate fish near the top of the intake where they would be guided into the gatewell by the gatewell deflector. Field testing of both guiding devices should be conducted.

The Rock Island first powerhouse is operated secondarily to the 2nd powerhouse with most of the river flow passing through the 2nd powerhouse. However, the 1st powerhouse does operate when flow conditions and operational plans allow. The distribution of smolts approaching Rock Island and passing through the 1st or 2nd powerhouse is uncertain. Past studies at other projects generally show that the fish will follow the predominant flow. The proportion of fish passing a point will likely be roughly equal to the proportion of flow passing the same point (Carlson, Acker, Gaudet). The smolt distribution will probably depend upon the operational modes of the two powerhouses. The structural designs of intakes of the 1st powerhouse at Rock Island is similar to the design of the powerhouse at Rocky Reach Dam.

Evaluation and design of a turbine intake deflector collection system should proceed for Rock Island 2nd powerhouse. Hydraulic model tests of

alternative gatewell deflector designs should be conducted. A field test of a small deflector should be conducted. Horizontal and vertical distribution studies relative to various spill and operational modes should be conducted at both powerhouses simultaneously. This would aid in determining an appropriate collection and bypass system for the 1st powerhouse.

Scope of Work: A complete study plan to meet the following objectives and required data should be developed.

I. Design and evaluate an intake collection system for the 2nd powerhouse.

   A. Conduct hydraulic model tests of deflector designs and types.

   B. Field test a gatewell deflector.

   C. Field test a trash rack guiding device.

II. Determine the vertical and horizontal distribution of smolts approaching the 1st and 2nd powerhouses respectively under varying spill and operational modes.

   A. Utilize hydroacoustic monitoring, bypass trap sampling, and cooling water intake sampling.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program research and installation of a prototype bypass system and the installation of a complete bypass system at Rock Island Dam. Until such

time as a complete bypass system is operational at Rock Island Dam, sufficient spill shall be provided to minimize juvenile salmonid losses during the spring and summer migration periods.

Task 1.3.9: Install juvenile bypass system at Wells Dam.

Wells Dam has a unique design when compared to other Columbia and Snake River hydroelectric projects. They hydro combine design is comprised of a spillway super-imposed on the powerhouse structure.

A minimal spill program is conducted during the spring migration to attempt to aid passage of juveniles. Migration monitoring with hydroacoustic equipment has provided some smolt passage and distribution data but final study results are not available. The effectiveness of spill in the small amounts provided for passing fish has not been determined at Wells Dam.

During 1980 a turbine versus spillway mortality test was conducted at Wells Dam. The study results showed that turbine mortality was approximately 16 percent (Parametrix, 1980).

Hydroacoustic monitoring to determine timing of migration and fish distribution across the powerhouse was conducted in 1981. Results of these studies are not yet available.

Basin data regarding juvenile migrant approach to the dam are required for design and development of a collection and bypass system. Once this information on passage distribution is available, collection and bypass options can be explored. If fish are concentrated near the surface or localized in some areas, surface spill potential could be explored. However, if migrants sound to enter the deep intakes at Wells then turbine intake collection and bypass options should be pursued.

Scope of Work: Complete and detailed study plans should be developed to meet the following objectives and produce the required data for development of a juvenile bypass system.

I. Determine horizontal and vertical smolt distribution and approach the powerhouse. Utilize hydroacoustic methods.

II. Conduct engineering feasibility studies of turbine intake deflectors and bypass conduits to tailwater.

A. Measure flow pattern and velocity in the intake.

B. Evaluate alternatives for development of a conduit bypass to tailwater.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program research on a prototype bypass system followed by installation of an efficient, complete bypass system at Wells Dam. Until such time as a complete bypass system is operational at Wells Dam, sufficient flow shall be provided to minimize juvenile salmonid losses during spring and summer migration periods.

Task 1.3.8: Install juvenile bypass at Rocky Reach Dam

Rocky Reach Dam has operated since its construction in 1955 without juvenile downstream migrant protection. A minimal spring spill program of questionable effectiveness is provided to attemmpt to aid migration past the project. There are no present or future public utility district plans to develop or install a collection and bypass system at Rocky Reach.

During 1980 a spillway survival study was conducted at Rocky Reach Dam. The study concluded that less than 2 percent mortality occurred to fish passing over the spillway (Hienle and Olson). A system mortality study conducted in 1980 showed that substantial mortalities of 17 - 25 percent per dam occur through the five-dam public utility district system including Rocky Reach Dam (Chapman and McKenzie).

Sonar is utilized at Rocky Reach Dam to monitor downstream migration. Sonar monitoring does not include fish passing through the powerhouse. The effectiveness of the spring spill program, 10 percent of the river flow, has not been measured at Rocky Reach. Studies at other projects show that fish passage is proportional to flow (Carlson, Acker, Gaudet) (Sims, Williams, et al., 1981).

Limited gatewell dipping and forebay sampling has occurred at Rocky Reach (Hays, et al., 1978). In 1980 gatewell sampling was conducted primarily in conjunction with downstream migrant monitoring and tag recoveries. These

efforts showed that a moderate number of fish entered intakes one and two on their own volition (Parametrix Inc., 1980).

A prototype turbine intake collection and bypass system should be installed and evaluated to reduce juvenile downstream migrant mortalities.

Initial indications from limited fish distribution data indicate that fish might collect at the downstream portion of the powerhouse. This must be confirmed and additional distribution data must be collected to determine the most appropriate collection and bypass system.

A prototype gatewell collection system should be tested at Rocky Reach. Research completed to date at other projects indicate that a combination barrier screen and airlift system may be successful at Rocky Reach to guide fish into gatewells and remove them from the gatewells. Past research has shown that without guidance devices insufficient numbers of fish enter the gatewells to meet passage criteria.

Testing a prototype airlift system in several units would determine horizontal distribution of smolts across the powerhouse. If horizontal distribution data shows that a natural collection of fish occurs at the downstream portion of the powerhouse, a surface collector or skimmer might be appropriate.

Scope of Work: Complete study plans should be developed to meet the following objectives and to produce the required data.

I. Determine horizontal and vertical smolt distribution at the powerhouse.

A. Utilize hydroacoustics;

B. airlift protypes

C. barrier screens.

II. Conduct hydraulic model studies and velocity measurements to determine the most appropriate design for a vertical barrier screen or other guidance device.

III. Test and evaluate the operation of an airlift and vertical barrier screen system.

IV. Evalute the alternatives for development and construction of a conduit system from gatewell collectors tailwater.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program research on prototype bypass system and then installation of an efficient complete bypass system at Rocky Reach Dam. Until such time as a complete bypass system is operational at Rocky Reach Dam, sufficient spill shall be provided to minimize juvenile salmonid losses during spring and summer migration periods.

Task 1.3.10: Install juvenile bypass facilities at Ice Harbor Dam

Introduction: Ice Harbor Dam was the first of four run-of-the-river hydroelectric projects constructed on the lower Snake River by the Corps of Engineers. It was initially placed in service in 1961 and powerhouse generating capacity was doubled in 1975.

Studies of turbine intake deflector screens were initiated in 1969 at Ice Harbor by the Corps of Engineers and National Marine Fisheries Service. Gatewell orifices were installed and a temporary bypass flume was constructed within the existing ice and trash sluiceway. Traveling screens were found to be effective in diverting fish into the upstream gatewell slot. A vertical barrier screen within the gatewell to prevent fish from entering the downstream gatewell slot was found to be needed. Associated survival studies identified the importance of selecting release sites for bypassed fish (Long, 1968). It was found that fish released into the turbine backroll area of the tailrace channel near the powerhouse suffered a mortality rate of approximately one-third.

Following completion of studies at Ice Harbor Dam, the temporary flume was removed. The 6-inch orifices were left in operation to pass fish accumulating in the gatewells. No method of collection to divert fish into the gatewells is currently provided. The ice and trash sluice is currently operated during the spring migration as a surface skimmer but its effectiveness is not known.

Functional evaluation of the existing skimmer collection method is required to determine whether it can be operated consistently at better than 70 percent bypass efficiency for all species migrating past Ice Harbor. Installation of an intake screen - orifice bypass system similar to that in use at McNary Dam is feasible. If a two-year evaluation of sluiceway passage efficiency in 1982 and 1983 does not indicate this method can be refined into an effective bypass system, then the orifice bypass system will require renovation and installation of turbine intake screens. A three-year evaluation of this system would be required to evaluate its effectiveness, identify required structural and operational improvements, and evaluate needed information.

Current Status: Despite mass transportation of juvenile salmonids from Lower Granite and Little Goose dams, large numbers of juvenile salmonids still pass Ice Harbor Dam. Presently, there is no approved juvenile bypass system at Ice Harbor. Costly volitional spilling is required to protect fish during periods of peak migration. Ice Harbor Dam is equipped with an ice and trash sluiceway which can be operated as a surface skimming bypass system. The efficiency of this bypass system is unknown. Presently, there are obstructions (electrical conduits) in the lower passageway of the sluiceway which limit the amount of flow which can be discharged through it. Studies at other Columbia River dams have shown that the attraction of juvenile salmonids into the sluiceway is directly related to the amount of flow which can be passed through it. Therefore, it will be necessary to completely clear the lower sluiceway passageway at Ice Harbor in order to determine optimum operating criteria for its operation as a bypass system. Likewise, it is

necessary to determine optimum operational criteria before the efficiency of the sluiceway as a bypass sytem can be evaluated.

Little research which would aid in the determination of the efficiency of the Ice Harbor sluiceway as a bypass system has been conducted in the past. Past gatewell dipnetting data may be of some use. However, most was collected before completion of the last three power generating units in 1976, and the small quantity of data was collected later with other objectives in mind.

A considerable amount of information from studies on the use of sluiceways at Bonneville Dam and The Dalles Dam as juvenile bypass systems has been generated by Oregon Department of Fish and Wildlife. Much of the information and understanding derived from these studies can be used to guide an evaluation of the Ice Harbor sluiceway.

Needed Research: A thorough evaluation of the Ice Harbor sluiceway as a juvenile bypass system should be made. This would include identification of optimum operational criteria for bypassing juvenile salmonids on a species-by-species basis and a direct evaluation of the bypass efficiency for each species when the sluiceway is operated according to optimum criteria.

A major effort to restore fall chinook runs in the Snake River is currently being undertaken. Evaluation of the Ice Harbor sluiceway as a bypass system should include an evaluation of fall chinook bypass efficiency. Studies by Oregon Department of Fish and Wildlife at dams on the lower Columbia River have indicated that the fall chinook outmigration peaks late in

the summer (July and August). A study to evaluate bypass efficiency of fall chinook at Ice Harbor Dam should extend at least through the month of July.

Historically, spilling has occured at Ice Harbor on an annual basis (primarily in May). Research at The Dalles Dam indicated that spilling had a significant impact upon fish distribution at the powerhouse. Powerhouse distribution has a significant impact on optimum operational criteria for the sluiceway. Consequently, it is necessary to determine the effect of spilling at Ice Harbor on the distribution of juvenile salmonids along the powerhouse. If the distribution is different under spill and no-spill conditions, then optimum operational criteria should be developed and bypass efficiency evaluated under both spill and no-spill conditions.

The mortality to juvenile salmonids associated with sluiceway bypassing should be determined as part of the evaluation of the effectiveness of this system.

Other factors which should be investigated include the seasonal and diel patterns of attraction of fish into the sluiceway and the effects of powerhouse loading, forebay water level, trash accumulation, and other such environmental variables on the effectiveness of the sluiceway as a bypass system.

If it is determined that the unaltered sluiceway is only partially or inadequately effective at bypassing juvenile salmonids, modifications that could increase bypass effectiveness (such as sluice-scoops or partial screening of

the powerhouse) or alternative bypass systems (such as complete screening of the powerhouse) should be investigated.

Thorough investigation of the Ice Harbor sluiceway as a juvenile bypass system will require from two to three years of research.

Products or Results Expected from Research: The mortality to migrating juvenile salmonids associated with turbine passage at Ice Harbor Dam will be substantially reduced by development of an effective juvenile bypass system. The ice and trash sluiceway offers the potential for providing an effective bypass system at the lowest possible cost. A determination of bypass efficiency using the sluiceway will allow administrators to decide whether it will be adequate or whether alternative systems should be investigated. If adequate, the study will provide operational criteria for optimizing juvenile bypass efficiency using the sluiceway.

Scope of Work: An evaluation of the juvenile bypass efficiency of the Ice Harbor sluiceway should include the following objectives:

1. Determine the horizontal distribution of salmonid entry into the powerhouse under spill and no-spill conditions when the sluiceway is not operating. This and the following objectives should extend from April 1 through July 31 so that all species, especially fall chinook, will be thoroughly evaluated.

2. Determine optimum operating criteria for the sluiceway under spill and no-spill conditions. This objective should include a determination of the

effect of open sluicegates on the attraction of salmonids into the sluiceway, a determination of the depths of individual gate openings required to balance flows among a combination of open gates to achieve optimum fish attraction and a comparison among alternative flow patterns identified by the above activities to determine the relative fish attraction characteristics of each.

3. Determine the efficiency of the sluiceway as a salmonid bypass system under spill and no-spill conditions. This objective should involve direct estimates of total powerhouse passage and sluiceway passage which, when compared, provide a reliable estimate of sluiceway bypass efficiency under optimum operation conditions. It should also include a determination of mortality associated with sluiceway bypassing, a determination of seasonal and diel patterns of salmonid attraction into the sluiceway, and a determination of the effects of ambient environmental factors (such as powerhouse loading, forebay water level, and trash accumulation) on the passage of salmonids through the sluiceway.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program necessary research at Ice Harbor Dam to determine the effectiveness of sluiceway operation as a means of juvenile bypass, and complete any modifications required to provide an efficient bypass system. Until such time as a suitable bypass system is operational at Ice Harbor Dam, sufficient spill shall be provided to minimize juvenile salmonid losses during spring and summer migration periods.

Task 1.3.11: Install juvenile bypass facilities at Lower Monumental Dam

Lower Monumental Dam was the second of four run-of-the-river hydroelectric projects constructed on the lower Snake River by the Corps of Engineers. It was placed in service in 1969 and expansion of the powerhouse ot its present capacity was completed in 1979. Lyons Ferry Hatchery, in Lower Monumental pool, will begin production in 1982.

The project was constructed with 6-inch gatewell orifices connected to a small closed bypass conduit similar to the system initially installed at John Day Dam. As at John Day, the limited flow through this system has proven ineffective in attracting accumulated fish out of the turbine intake gatewell. No means of collecting or concentrating fish in the gatewells is provided.

Juvenile survival studies were conducted at Lower Monumental Dam by National Marine Fisheries Service in 1972, 1973, and 1974 (Long, et al, 1972; Long and Ossiander, 1974; Long, et al, 1975). The emphasis of these studies was an evaluation of the effects of spillway flow deflectors and slotted bulkheads as nitrogen dissipators but other components of powerhouse and tailrace mortality were also assessed. It was concluded that fish passing through perforated bulkheads would experience no greater losses than if they went through a standard turbine operating at normal overload condition.

A turbine intake screen-gatewell orifice bypass system similar to that installed at Little Goose Dam is feasible but will require reconstruction of the existing orifice and conduit system. Criteria developed during bypass

intallation and evaluation at Little Goose and John Day Dams can largely be applied to design of the Lower Monumental juvenile bypass system.

It is recommended that the Corps of Engineers proceed at this time with engineering and design activities leading to completion of reconstruction of the gatewell orifice and conduit system by 1985. Installation of vertical barrier screens and submersible traveling screens (STS) of the type utilized at Little Goose Dam should be installed concurrent with completion of bypass reconstruction. The STS design should take advantage of recommendations for modifications to the Little Goose screens. Evaluation of the completed bypass system and correction of operational and structural discrepancies should be carried out in 1985 and 1986.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the installation of intake screens and provide other modifications needed to provide an efficient bypass system at Lower Monumental Dam by the Corps of Engineers. Until such time as a complete bypass system is operational at Lower Monumental Dam, sufficient spill shall be provided to minimize losses of juvenile salmonids during spring and summer migration periods.

Task 1.3.12: Improve juvenile bypass system at Little Goose Dam

Little Goose Dam was the third of the series of four run-of-the-river hydroelectric projects constructed by the Corps of Engineers on the lower Snake River. The project began operation in 1970. Expansion of the powerhouse to present generating capacity was completed in 1978. Downstream transportation of juvenile salmon and steelhead collected at Little Goose Dam has been conducted on an experimental basis since 1971 and on a production scale since 1975.

Little Goose Dam was constructed with 6-inch gatewell orifices and a closed conduit leading to tailwater downstream on the left shore. Three submersible traveling screens (STS) were installed in the powerhouse on an experimental basis in 1971. Testing in 1971 (Ebel, et al., 1971) and 1972 (Ebel, et al., 1973a) indicated that the screens were effective and the remainder of the turbine intakes were subsequently screened.

The bypass conduit was reconstructed in 1979 and 1980 to increase the gatewell orifices to 12-inch diameter and enlarge the bypass collection channel and conduit to a larger capacity system similar to that in use at Lower Granite Dam. On the basis of 1977 and 1978 studies of screen modifications (Park, et al., 1978, 1979), the original STS were replaced in 1981 with redesigned screens of the same type in use at McNary Dam.

Developmental and evaluation studies of intake screening and bypass facilities at Little Goose Dam were initiated by National Marine Fisheries

Service in 1971. This initital three-year study demonstrated that STS could be effective in deflecting more than 80 percent of downstream migrant juvenile salmon into the intake gatewells (Ebel, et al., 1971, 1973a, and 1973b). During regular operations such high defection rates have not been attained yet on a regular basis. This and subsequent studies (Ebel, et al., 1974; Park, et al., 1978, 1979) defined structural and operational improvements to the bypass system and led to redesign of the intake screens and reconstruction of the orifice and conduit system.

Operation of the new bypass system began in the spring of 1980. Daily mortalities of juvenile chinook salmon and steelhead were excessive until the make-up valve was shut down. The make-up valve automatically adjusts the water flow through the fingerling bypass system after initial water level is set.

In 1981 the make-up valve was modified to prevent any sheer plane action in the gallery. The system continued to have high fish motalities even though the make-up water system was modified. Engineers now feel that the problem lies within the hopper system which joints the bypass gallery to the transport pipe.

To prevent fish mortalities from occurring in the bypass system, water level in the hopper was reduced. However, this mode of operation caused air to be entrained in the system. Problems caused by this operation were: (1) a small percentage of the fish examined in 1981 had "gas bubble" disease or nitrogen bubbles in their fins, and (2) water surging at the upwell made it impossible to evaluate the wet separator.

Modifications to correct problems existing in the hopper/transport pipe are scheduled to be designed and installed prior to the 1982 juvenile migration season. A remedied solution will not only reduce direct fish injuries and mortalities, but will also reduce surging and entrainment of air in the transport pipe.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the evaluation and possible modification of the juvenile bypass system at Little Goose Dam to be funded by the Corps of Engineers.

Subobjective 1.4: Minimize juvenile fish passage mortality at tributary hydroelectric projects

Characteristics of Juvenile Salmonid Outmigrants (Smolts):

In order to fully appreciate the juvenile outmigrant mortality problem, it is necessary to understand the physiological change juvenile salmonids experience prior to and during their transition to the saltwater environment. This process is referred to as smoltification. Although the phenomena is complex, fishery biologists have determined that during this transformation, salmon undergo biochemical changed that culminate in their ability to adapt osmotically to saltwater (Hoar, 1976). This process is accompanied by increased vulnerability during the outmigration.

Smolts have historically outmigrated in the spring during peak runoff periods, when high streamflows tended to flush them toward the ocean. This cushion of water provided for a low juvenile mortality rate due to the fact it was compatible with the relatively fragile smolt condition. The impact of dams and other manmade facilities have substantially increased juvenile mortalities, both on the Columbia River and on tributary and coastal streams in the Pacific Northwest.

Characteristics of smolting which contribute to this high mortality rate include:

Reduced Swimming Capabilities - The physiological changes that occur during smoltification result in changes in swimming efficiency that appear related to the progression of fish through the smolt transformation. Swimming performance in freshwater decreases progressively, with the maximum efficiency occurring concurrent to the period when the smolt gains a more silvery appearance. Swimming performances then become increasingly efficient as smolts adjust to the marine environment (Flagg and Smith, 1979).

Larger smolts retain a proportionately stronger swimming ability due to their size, while smaller outmigrants are swept along helplessly by the

current. Fall chinook smolts are the smallest, averaging approximately 80 mm, while steelhead smolts range up to 350 mm.

Reduced Resistance to Stress - The resting metabolism of smolts, as measured by oxygen consumption, was significantly higher than that of non-smolts of the same species (Flagg and Smith, 1979). This indicates a greater expenditure of energy required by outmigrants to sustain themselves at all levels of physical or psychological exertion. When exposed to various challenges, such as being drawn through turbines or other manmade facilities, the reduced critical fatigue levels of smolting outmigrants contribute greatly to high mortality levels.

Deciduous Scaling - As juvenile salmonids progress through the smoltification process, their appearance typically becomes more silvery concurrent to the peak of transition. This is accompanied by a tendency to easily descale. Descaling occurs when fish are injured mechanically, or when water temperature or turbidity is excessively high (Basham, 1981).

Outmigrants with greater than 10 percent descaling of the total body area died at the rate of 33 percent when held for a period of 120 hours. Fish with less than 10 percent descaling died at the rate of 2.7 percent when held for the same period. Some stress was undoubtedly incurred holding the fish in a confined area for that period of time.

This manifestation is not only an indication of previous injury, but also serves to reduce smolt protection from subsequent exposure.

Limited Smoltification Time - The smoltification lasts for only a limited period of time for juvenile salmon and steelhead (Raymond, 1979). If juveniles enter saltwater prematurely, or are delayed excessively, their chances of survival are greatly reduced. This subject is subsequently discussed in greater detail under the topic of delay.

The smoltification process is the complex transition that juvenile salmonids undergo immediately prior to and after their migration to saltwater. Several inter-related characteristics have been identified, but the more

complicated biochemical changes have only been attended to. The construction of dams and other manmade facilities have aggravated the already delicate life-cycle of salmon in the Pacific Northwest. The following account describes juvenile mortalities that result from the presence of hydroelectric projects on rivers with anadromous fish runs.

Impact of Dams Contributing to Juvenile Mortalities

Construction of dams have had many adverse impacts on the salmon life-cycle. Loss of valuable spawning and rearing habitat due to the presence of reservoirs is an example of one type of negative impact. Other problems are directly related to upstream and downstream passage. The mechanics of those problems are as follows:

Delay - Migration rate studies have shown that river velocity is directly proportional to the juvenile outmigration velocity. Impoundments have typically reduced migration rates of juvenile salmon and steelhead to one-third that of free-flowing stretches of river (Raymond, 1979). Passage success relates to the length and volume of the reservoir, the volume of flow through the reservoir at the time of migration, and the physical and biological make-up of the reservoir (Collins and Elling, 1964).

An illustration of outmigrant delays attributable to hydroelectric dams was studied and confirmed (Raymond, 1973) assessing smolt rates from the Salmon River. Migration from the Salmon to The Dalles Dam historically took approximately 24 days. It now takes nearly 65 days to cover that distance (Raymond, 1979). This delay has caused mortality due to juveniles passing the smoltification stage prior to reaching saltwater.

Significant delay, especially in low-flow years, results in the tendency for juveniles to hold over in reservoirs for extended periods before completing migration. Some spend their entire life-cycle in freshwater. A few may ultimately migrate to, and survive, the saltwater environment, but most are victims of disease due to temperature increased, predators, or starvation (Basham, 1981).

Many tributary hydroelectric projects, such as Round Butte Dam on the Deschutes River, have turbine penstock intakes well below the reservoir surface. Few smolts are drawn through the turbines because of the combination of high head and relatively low flows through the powerhouse. Smolts outmigrating through this type of reservoir experience downstream velocities approaching zero. Those that do migrate through the impoundment to the dam itself experience further delay finding the bypass or collection facilities. Delay is a greater problem for outmigrants at projects such as Round Butte than at locations with lower head and lower total reservoir volume.

Modification of flows below reservoirs from seasonably variable to more uniform has also been experienced. This reduced the magnitude of spring freshets which have historically aided the outmigration process.

Water Quality - The main water quality impact of tributary dams on the juvenile outmigration has been increase of water temperatures. In most cases, reservoirs impounded fast- moving coldwater rivers that were favorble to coldwater fish and unfavorable to warmwater fish. Impoundments elevated water temperatures, reduced currents, decreased dissolved oxygen concentrations, and increased rearing and breeding habitats for non-game, warmwater species (Willamette Reservoir System EIS, 1979). These fish are often predatory and compete for food with outmigrants. Elevated temperatures also have the effect of increasing juvenile salmonid vulnerability to diseases.

Downstream of tributary hydroelectric project sites, released water is usually either colder or warmer than historic temperatures. If water is released from lower elevations in a high-head reservoir, discharged water will be cooler and may not adversely effect outmigrants. Special provisions may be necessary for upstream migrants, however, due to a thermal barrier of excessively cold water that can greatly reduce habitat below the project and even terminate fish runs, if not mitigated for in a timely manner. Cougar Dam on the South Fork McKenzie River is an example of where this has occurred. A hatchery was constructed to mitigate the reduced run size.

Turbine Mortality - When hydroelectric dams were originally constructed in the Northwest, it was felt that providing adequate upstream passage was sufficient to sustain salmon and steelhead runs. Since that time, it has been shown that the percentage of smolts surviving turbine passage is alarmingly low.

As smolts are drawn through turbines, they are exposed to conditions which can cause death to juveniles in a variety of ways. Mechanical injuries are caused from direct contact with equipment and cause abrasions, contusions, or lacerations. Pressure-related injuries are manifested by fish with popped eyes, or those with gill hemorrhaging, but no other signs of injury. These problems are associated with negative pressures and cavitation near the turbine runner or blade. Shearing action of water also causes injuries, including those characterized by torn operculums or broken gill arches, which cause smolts to bleed to death. Mortalities with no visible sign of injury are usually caused by excessive stress (Fish Passage Tests, Corps of Engineers, 1961).

Francis turbines are commonly used for hydroelectric projects with over 100 feet of head. Findings indicate that juvenile survival through this type of turbine depends upon the efficiency, wicket gate openings, size of fish, and other variables of the unit. At other than rated loads, efficiencies drop rapidly and mortalities increase due to the greater severity of the adverse conditions previously stated. Survival under optimum conditions at Cushman No. 2 hydroelectric plant varied from 89.3 percent for steelhead smolts to 68.9 percent for the smaller chinook juveniles (Fish Passage Tests, Corps of Engineers, 1961).

Kaplan turbines are used on most of the mainstem Columbia and Snake River hydroelectric projects, but are also used on many tributary projects as well. This type of turbine is customarily used at locations where heads are 100 feet or lower. Survival of smolts through Kaplan turbines was also determined to be dependent on turbine variables such as efficiency, percent of full load, wicket gate openings, etc.(Bell, et al., 1967). Turbine mortality studies ve shown juvenile losses as low as 7 percent, which does

not necessarily reflect delayed mortalities to as high as 30 percent (Snake River Salmon and Steelhead Crisis Report, 1975).

Spillway Mortalities - In many hydroelectric projects on tributary streams, there simply are no fish facilities for outmigration. Smolts must pass through turbines or spillways before continuing downstream. In instances of relatively high-head dams such as Baker Dam on the Baker River in Washington, where the dam reaches a height of 250 feet, outmigrants using spillways incurred 54 percent losses for coho and 64 percent losses for sockeye. At Baker Dam, 95 percent of the smolts used the spillway gates rather than turbine intakes, which were 85 feet below the forebay water surface (Hamilton and Andrews, 1954). Injuries were mainly caused by abrasion, pressure changes, and cavitation. Modifications were subsequently made to reduce spillway losses.

While only limited research has been conducted concurring juvenile spillway mortalities, it is apparent that there is not a significant problem at low-head dams, especially where a spilling basin of suitable depth exists. At medium and higher-head dams, and locations where rock outcroppings exist below spillways, there could be appreciable mortality problems.

Bypass Systems Which Have Yielded Satisfactory Passage

Rotating Drum Screens - Fishery agencies have developed design criteria for this type of system. As water is drawn from forebay, it passes through a bank of circular screens, with a horizontal axis. Velocities through screens are limited to 0.5 or 1.0 feet per second, depending on the size of fish. Maximum opening size varies from 0.14 to 0.25 inches, which keep smolts from passing through the screens. Bypass ports are located immediately upstream of screens, and in such a manner that juveniles will be drawn into them, then carried to tailwater. This type of screen is self-cleaning and requires relatively little maintenance. Installations of this type are commonly used for irrigation and smaller hydroelectric projects. Drum screen systems require a considerable amount of space. Wapatox Dam on the Naches River employs rotating drum screens.

Excessive velocities through drum screens, or inadequate bypass collection, can cause higher mortality than passage through turbines. Juveniles tend to become impinged, especially when bypass ports are at remote locations. Bypass prots should be large enough to minimize debris buildup and have high enough velocity to draw fish. Fish should not be required to search until they locate the bypass entrance. Additionally, seals must be maintained to minimize smolt passage.

Vertical Traveling Screens - Vertical traveling screens have been used effectively at hydroelectric dams on the Snake and Columbia, but have been used only sparingly on tributary projects. Criteria is basically the same as for drum screens, however the geometry is such that economy of space can be realized. Powerdale Dam on the Hood River is an example of where vertical screens are used effectively.

Stationary Inclined Screens - This concept involves the same design criteria as drum screens and vertical traveling screens. Water passes through screens at a slight angle to the direction of flow. Velocity normal to the screen is either 0.5 or 1.0 ft per sec. A larger component of velocity continues parallel to the screen face and carries small debris and fish to a bypass location, then down to tailwater. The inclined screen concept is used on a smaller, permanent scale at Bonneville Second Powerhouse to pass juveniles, while screening 800 cfs. Automated cleaning has been provided for at that location. Submerged traveling screens are used in the turbine intakes at that location.

Louvers - Briefly stated, louvers panels are constructed of flat steel bars, with approximate 1 in. openings. Juveniles and bypass water move along the louver panels in a channel of decreasing cross-sectional area toward the bypass. Turbine intake water is continually drawn through the louvers. At any given point, the component of downstream velocity is greater than that through the louver openings. The idea is that fish will resist being drawn through louvers, and will finally be drawn into the bypass at the lower end of the louver system.

This concept has been found to be marginally satisfactory for steelhead and larger spring chinook smolts. For this reason, louvers are not recommended for most locations where other than steelhead smolts are present.

A number of juvenile bypass systems have been used on tributary hydroelectric projects in the Pacific Northwest, almost uniformly with less than satisfactory results. Typically, funds have not been allocated to construct adequate bypass facilities because of low calculated benefit-cost ratios. The cumulative effect has been the depletion of salmon and steelhead runs because reduced numbers of smolts are reaching the estuaries. Project locations with juvenile collection facilities which have not functioned adequately have not had modified systems implemented. At most of these locations, the losses have been mitigated by the construction of hatcheries, which release a fish less adapted for survival in the wilds.

Depletion of wild anadromous fish runs in the Columbia Basin can be blamed primarily on the construction of dams. The magnitude of the problem is illustrated by the fact only one third of the original spawning and rearing areas in the 250,000 square mile watershed of the Columbia River is still accessible to salmon and steelhead (Schwiebert, 1977).

Categories of Tributary Hydroelectric Projects with Regard to Juvenile Outmigration

1. Projects with Adequate Bypass Facilities - There are few tributary hydroelectric projects in the Pacific Northwest that have satisfactory outmigrant passage facilities. The Powerdale project, on Hood River, has vertical traveling screens that work well while the Wapatox project, on the Naches River, has drum screens that are considered adequate. For high head dams the Green Peter and North Fork Clackamas Projects have the best operational downstream migration facilities.

2. Projects with Inadequate Operational Bypass Facilities - Some projects have bypass facilities along the lines of those recommended by fish agencies, but with major inconsistencies. Cougar Dam on the South Fork

McKenzie combined a downstream migrant facility with the water control structure which resulted in high mortality to juvenile migrants.

At Roza Dam, on tne Yakima River, drum screens have been constructed, but are inadequate due to excessive velocities through the screens. Significant numbers of the outmigrants are impinged on the screens, resulting in their death. The problem was studied and documented 20 years ago, but improvements have yet to be made.

3. Projects Without Operational Bypass Facilities - This type of hydroelectric project includes those which had inadequate, abandoned bypass facilities and those which had no juvenile bypass when constructed. Most of these projects have had hatchery mitigation to compensate for anadromous fish losses. Some, such as Condit Dam on the White Salmon River, have no passage facilities, and fishery losses are not being mitigated.

Mitigation

Historically, fishery agencies have not been able to insure timely and adequate mitigation for losses of access to valuable habitat, and subsequent reduced anadromous fish returns. This frequently depends on a lengthy evaluation process after the completion of each hydroelectric project, and the willingness of the owner organization to provide funds at a later date. There has never been adequate leverage to insure additionally required compensation is provided. The result is that some salmonid species are no longer present in some water sheds where they once thrived. Moreover, the number of salmon and steelhead smolts reaching estuaries continues to decrease. Of those that reach the ocean, an increasing percentage are from hatcheries, and are not as well adapted for survival as wild fish.

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Task 1.4.1: Sandy River Basin

Introduction: Marmot Dam owned and operated by Portland General Electric (PGE) on the Sandy River, diverts 600 cfs from the Sandy through Marmot Canal into generators on the Bull Run Hydroelectric Project. Populations of juvenile chinook, coho, and steelhead, both wild and hatchery, emigrating out of the upper Sandy are subject to delay, mortality, or diversion into Roslyn Lake which serves as the forebay of the hydroturbines at the Bull Run Project.

Current Status: Chronic problems with ineffective screen diversions of emigrants out of Marmot Canal over the years have been met with frequent facility modifications by PGE. Prior tests have indicated that small chinook are not adequately diverted out of the canal by the then-existing facilities (Hansen, 1976; Clark, 1975). Other species may be similarly affected. This earlier research, however, is only preliminary in nature and not sufficient to base modification of the existing screening facility. Also, the facility has received minor modifications from earlier years.

Since potential anadromous fish production in the upper Sandy River is large, and demand for these fish is great due to the proximity of the stream to Oregon's largest center of population, it is critical that safe passage of emigrants which are jeopardized by Marmot Dam and power canal be assured.

Development of the fishery resources of the upper Sandy River has been retarded by the emigrant protection problems at Marmot Dam. Management biologists have hesitated to release hatchery smolts into stream areas above Marmot, knowing that heavy losses will likely result when these emigrants are forced to negotiate the questionably-effective bypass system. Juveniles resulting from natural spawning of adults may be even more severely affected, since wild emigrants are commonly smaller than hatchery-related emigrants and the diversion efficiency at the screens appears size-related.

A comprehensve evaluation of the present screening facilities must be conducted to determine if safe and undelayed passage is being provided. PGE and the Oregon Department of Fish and Wildlife has initiated and is funding a two-year evaluation to determine if screening modification or replacement is required.

Scope of Work: Tasks necessary to evaluate Marmot Diversion System include:

1. Release marked populations of chinook, coho, and steelhead smolts into the Sandy River above Marmot Dam. Recapture of these fish in the Marmot bypass trap over time will define:

    A. How effectively the bypass sytem transports numbers of fish released.

        1. Sample in the canal behind the screen to indicate undiverted migrants.
        2. Sample in Roslyn Lake to indicate undiverted migrants.

    B. Potential delays in emigration resulting from the screen/bypass system (passage vs emigration timing).

    C. Mortality and injury rates ascribable to the diversion/bypass system.

2. Relation of current data to previous tests.

3. Recommendations for modifications of the system, if necessary.

4. Re-evaluation of any facility modifications that may result.

5. Recommend final solution for bypassing juveniles at Marmot Dam.

Recommendation: That the Power Planning Council provide programmatic support of the bypass evaluation and include in the Fish and Wildlife Program

improvement of the screening facilities should the current investigation indicate unsafe or inefficient passage of juvenile salmonids and fishery compensation for any reasonable level of unavoidable loss.

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Task 1.3.13: Improve juvenile bypass system at Lower Granite Dam

Lower Granite Dam was the last of the series of four run-of-the-river hydroelectric projects constructed by the Corps of Engineers on the lower Snake River. The project began operation 1975 and was expanded to its present generating capacity in 1978.

Lower Granite Dam was the first of the Columbia River dams designed to specifically accommodate turbine intake traveling screens. An open flow bypass channel was provided within the powerhouse to remedy the problem of limited hydraulic capacity experienced in earlier gatewell orifice and conduit designs such as those at Little Goose and Lower Monumental dams. A third gatewell slot upstream of the two usual slots was provided at each intake to facilitate submerged traveling screen (STS) use. This third slot was found to be too far upstream for effective screen operation and the emergency or bulkhead gatewell slot has been utilized here as at other projects. The bypass system utilizes two 8-inch orifices per gatewell opening into the bypass channel with a 42-inch conduit to tailwater downstream on the left bank. The system includes a separator and trapping facility for marking and transport activities.

There is substantial natural production of salmon and steelhead upstream of Lower Granite Dam in the Salmon, Clearwater, Grande Ronde, and Imnaha drainages as well as several major hatchery facilities. Hatchery production in this area is now being increased as part of the Lower Snake River Compensation Plan. Due to concern about the rapidly declining numbers of

salmon and steelhead returning to the Snake River, downstream transportation of juvenile fish was initiated at Lower Granite Dam in 1975 and is continuing.

An evaluation of juvenile fish protective facilities at Lower Granite Dam was initiated by National Marine Fisheries Service in 1975 (Park et al., 1976, 1978, 1979). The 8-inch orifices used at Lower Granite were found to be much more effective at reducing delay of fish in intake gatewells than the 6-inch orifices used in previous designs. Use of the third or upstream gatewell slot for traveling screens was found to result in increased descaling and reduced guidance efficiency. Best guidance efficiency was observed for STS set at an angle of 50° to 65° from vertical. Lighting the intake screen was also observed to produce some increase in guidance. Lighting the gatewell orifices was observed to be effective in attracting fish into the bypass channel.

The submersible traveling screens have undergone several structural and operational modifications since their installation at Lower Granite. Tests of screen mesh sizes, perforated plate backup, operating angle, etc., led to several basic design changes which were adopted in the latest model screens. These modifications which produced higher efficiency or better survival have included increasing the throat width, increasing the gap between the screen and gatewell beam, and changing the operating angle. These modifications have not as yet been evaluated as to their effect on operating efficiencies.

An evaluation to determine current bypass operating efficiency and to identify deficiencies in the passage facilities is needed and can be conducted during 1982 and 1983. This should be carried out in conjunction with a

program to implement needed operational and structural improvements and determine the effectiveness of such modifications.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the evaluation and possible modification of juvenile bypass facilities at Lower Granite Dam by the Corps of Engineers.

Task 1.4.3: South Santiam River, Foster Dam

Introduction: The Corps of Engineers operates Foster Dam on the South Santiam River. Because the dam is a relatively low head dam, when the project was planned and constructed, downstream migrants were expected to sound 6 to 15 m below the surface, depending on the reservoir level, and pass through turbines or under the spillway gates. Juvenile spring chinook and sockeye appear to successfully pass Faster Dam but the native winter steelhead run has declined from an estimated 1,900 adults to less than 500 annually from 1973 to 1981. Studies have shown that steelhead smolts released into the forebay of Foster Reservoir were only one-fourth as successful in their downstream migration as comparable groups released immediately in the tailrace of Foster Dam. (Buchanan, 1980)

Current Status: Wagner and Ingram (1973) believed that only small numbers of wild steelhead smolts entering Foster Pool from the Upper South Santiam or Middle Santiam after April successfully emigrated from the reservoir during the primary migration season. The primary migration timing for wild steelhead smolts in the Willamette system was first reported from Massey (1967) who noted in 1964 and 1965 that movement occurred from April to early July, with the peak in early May. Buchanan (1975 and 1976) reported that Foster Dam reduced adult returns from summer steelhead smolts released either into Foster Reservoir or into the South Santiam above the reservoir when these were compared to similar groups released immediately below Foster Dam. Delays in steelhead outmigration from Foster Reservoir were also shown

from creel surveys in 1974, 1975, and 1976 (Buchanan 1975 and 1976; Moring 1975 and 1976). Buchanan (1976) determined that Willamette native winter steelhead smolts are highly susceptible to bacterial diseases in the main Willamette River when water temperatures are greater than 17°C. If winter steelhead smolts are delayed at Foster Dam in the spring and do not move downstream into the cooler Columbia River before Willamette water temperatures reach 17°C, which usually occurs in mid-to-late May, substantial mortalities will occur.

A research study is necessary to develop techniques to alleviate the passage problem. The first phase of this study should determine if the combination of surface-oriented spill and reduction of reservoir level will improve downstream passage during the spring emigration period. If this phase is not successful, alternative studies may include (1) structural modifications of a spillway or construction of a separate downstream migrant facility at Foster Dam, (2) collecting steelhead smolts at the Green Peter downstream facility and trucking them around Foster Dam, (3) evaluation of hatchery mitigation to replace lost steelhead (this option would be used only if all other options fail).

A four-year study has been funded by the Corps of Engineers to study Phase I. A satisfactory solution has not yet been achieved after three completed years. One additional year (October 1981 to September 1982) will complete Phase I of the study. We believe that three additional years will be necessary to study the alternative phases and arrive at a final solution. The estimated study costs for FY-83 would be $80,000 with a total funding requirement for three years.

The expected result is a final solution to the downstream migration problem at Foster Dam. The native winter steelhead run above Foster Dam should be re-established to at least the average annual pre-impoundment level of 1,900 returning adults. It should be studied in phases with the most beneficial phase in terms of economical, recreational, and social opportunities conducted first. Re-establishment of wild production in the upper South Santiam system could reduce BPA rate payer expense for hatchery replacements and increase angling opportunities in the upper South Santiam River. Lesser options such as hatchery mitigation to replace lost steelhead would be a continuing burden on BPA rate payers.

Scope: The following objectives need to be addressed to complete Phase I of the study:

Objective 1: Install stoplogs, lower Foster Reservoir, and open the Tainter gate so that 250 to 330 cfs surface water can spill in a freefall to facilitate steelhead smolt emigraton.

Objective 2: Determine timing and number of hatchery Willamette winter steelhead smolts emigrating through the Green Peter downstream migrant facility.

Objective 3: Determine timing and number of wild steelhead smolts emigrating past Green Peter Dam.

Objective 4: Determine if mortality or injury will occur when steelhead smolts are passed freefall over stoplogs and onto the spillway.

Objective 5: Determine emigrating success of hatchery steelhead smolts from the Willamette stock released in the tailrace of Foster Dam, in the forebay of Foster Reservoir, and from Green Peter Reservoir.

Recommendation: That the Power Planning Council provide programmatic support for the fish passage research being funded by the Corps of Engineers and include in its Fish and Wildlife Program the goal of safe and efficient fish passage at Foster Dam to be achieved pending result of ongoing studies, and fishery compensation for any reasonable level of unavoidable loss.

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Task 1.4.4: South Santiam River, Lebanon Dam

Introduction: Lebanon Dam is located 26 km downstream from Foster Dam on the South Santian River. It is a concrete sill dam approximately 2 m high. Water is diverted at Lebanon Dam into Lebanon Canal for municipal use and power use at a power plant in Albany. Approximately 100 cfs flows in the diversion canal. Pacific Power and Light operates a small turbine on the canal in Albany with a daily output of 250 to 300 kilowatts per hour. Juvenile spring chinook, sockeye, and steelhead can be found in the canal during their respective emigration periods.

Current Status: No fish protective screens exist at the entrance of Lebanon Canal. Power generation, therefore, only occurs 4 to 5 months in a given year. The remaining times are shut down for protection of emigrating salmonid smolts.

Diversion screens of the best current technology need to be installed at the entrance of the Lebanon Canal near Lebanon Dam. No major biological study would be required prior to construction. Cost to install screens is estimated to be $100,000. Fishery agencies would need to approve design of screens before installation and periodic monitoring after installation would be necessary to maintain adequate performance.

Once a diversion screen is installed at the entrance of Lebanon Canal, continuous generation of the canal water would be available. Increased power could be produced by Pacific Power and Light. In addition, year-round

screening of the canal could prevent downstream migrant salmonids from entering the canal at anytime.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the installation of effective fish screens and bypass system in the Lebanon Canal, and fishery compensation for any remaining unavoidable losses.

Task 1.4.2: Lower Willamette River

Introduction: The Portland General Electric Company (PGE) owns and operates a powerhouse, The Sullivan Plant, at Willamette Falls. Turbines in this lower Willamette River location jeopardize large populations of juvenile spring chinook, summer and winter steelhead, fall chinook, coho salmon, and sockeye which annually emigrate down the river. Protection for downstream migrants here would substantially improve the anadromous fisheries benefits provided by the entire upper Willamette River watershed.

Current Status: PGE's Sullivan Plant diverts approximately 5,000 cfs of Willamette River water into hydroelectric generators. During low flows, most of the entire river must pass through these turbines. Mortality effects on emigrating fish are related to river flow during emigration and fish size. Mortality is high when flow is low. Several powerhouse mortality studies have been conducted in the past, and mortalities up to 25 percent have been indicated (Wagner, 1977).

PGE has shut down the powerhouse during the juvenile outmigration to eliminate fish mortalities. In 1979-80 closures totaling 45 days were conducted. Losses of power at estimated replacement costs of $500/hr. (Doug Cramer, PGE, pers. comm) are considerable.

PGE has continued efforts to install effective emigrant protection devices on their generators. Currently, a lower diversion and fingerling bypass system has been installed and awaits evaluation as to (1) capability in moving fish past the turbines and (2) mortality effects on bypassed fish. A detailed study plan has been submitted to Bonneville Power Administration for potential funding.

Scope of Work: Objectives of bypass system evaluation are:

1. Evaluate the efficiency with which the forebay diversion facility in the Sullivan Plant safely transports four species of anadromous fish into Unit No. 13 (bypass unit).

2. Evaluate the efficiency with which the bypass screening Unit No. 13 at the Sullivan Plant safely transports four species of anadromous fish from penstock entrance to bypass pipe.

3. When effective diversion and bypass operation are defined, conduct mortality tests with spring and fall chinook to determine the degree of actual protection afforded by the facilities.

4. Establish mitigation replacement for any fish lost through bypass system.

Recommendation: That the Power Planning Council include in its fish and wildlife program the necessary bypass evaluation, improvement or replacement of the bypass system should study results indicate ineffective results, and fishery compensation for any reasonable level of unavoidable loss.

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Task 1.4.5: McKenzie River

Introduction: Leaburg and Walterville canals owned by Eugene Water and Electric Board (EWEB) divert approximately 2,000 cfs of water from the McKenzie River. This diverted water passes through hydropower turbines before being returned to the river. Substantial populations of juvenile salmon and steelhead emigrate through the affected portions of river and are jeopardized by turbine passage. The canals do not have fish screens and bypass systems. Partial fish protection has been provided since 1971 via strategic canal closures during critical times of downstream migration. These closures have lasted up to 90 days.

Current Status: Incomplete turbine mortality tests conducted with fingerling rainbow in 1957 indicated no more than 10 percent mortality associated with either of these projects (OGC 1958). However, gross mortality sustained by groups of smolt-size chinook salmon in transit through the entire diverted portion of the river was 47 percent (ODFW 1981, report in process).

EWEB is currently funding the Oregon Department of Fish and Wildlife to further refine the above mortality estimates and determine where the mortalities are occurring in the double canal system. The result of these studies will be a recommendation of how best to bypass juvenile migrants past these power projects.

Solution to smolt mortality at Leaburg and Walterville projects would provide a presently estimated improvements of 47 percent of the average annual run of 2,000 adult spring chinook which spawn above Leaburg Dam or an average increase of 940 adults. This represents current partial net benefits of approximately $439,000 annually for spring chinook alone. Additional benefits would accrue to the adult summer steelhead returns.

A permanent solution to the emigrant protection problem which would eliminate the need for canal closures would save EWEB $90,000 in annual costs. (Estimate for 1980 provided by Dale Hagey, EWEB Environmentalist.)

Recommendation: That the Power Planning Council provide programmatic support for the fish bypass evaluation at the Leaburg and Walterville projects and include in its Fish and Wildlife Program the construction of effective fish bypass facilities based on the results of the evaluation and fishery compensation for any reasurable level of unavoidable losses.

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Task 1.4.6: Yakima River - Roza

Screening facilities on the Roza power canal (Bureau of Reclamation) do not meet the fisheries agencies' screening criteria. The inadequacies of the Roza screens were studied from 1959 to 1962 by Washington Department of Fisheries and U.S. Bureau of Commercial Fisheries, and are documented in correspondence to the U.S. Bureau of Reclamation. Approach velocities are excessive (1.5 ft./sec. compared to .5 ft./sec. maximum allowed), and the fish bypass system is inadequate, resulting in fish being impinged on the screens. Bureau of Reclamation will be contacted to improve this situation, but needed expansion of the screening facilities will be extremely difficult due to lack of space (screens are now confined to an area between the river and railraod tracks). Improvement of the fish collection and bypass system can be accomplished within the space limitations.

Recommendation: That the Power Planning Council include it its Fish and Wildlife Program improved screening facilities at the Roza power canal to meet fisheries criteria and fishery compensation for any reasonable level of unavoidable loss.

Task 1.4.7: Naches River - Wapatox

The Pacific Power and Light Company (PP&L) owns and operates the Wapatox power project, a low-head diversion dam and canal, on the Naches River. A conventional horizontal-axis rotating drum screens and associated fish bypass system is installed near the entrance of the power canal to prevent fish from reaching the powerhouse. Considering the maximum flows which can be diverted, the screens are undersized according to current fisheries agency screening criteria. The design of the downstream migrant bypass facility, and the design of the screen structure in relation to the bypass could be improved based on the many years of fish passage research results since this project was constructed.

No recent evaluation of the screening and bypass system has been conducted. The screening facilities are not causing any obvious losses of fish, if all screens are used. In the past, PP&L has chosen not to utilize all of their available rotary screens which resulted in excessive approach velocities at the screens. This problem has been discussed with PP&L officials who have indicated that all screens will be used in the future.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the continued full operation and maintenance of the fish bypass facility at the Wapatox project and provision for improvement of the facility should observations and/or study indicate ineffective operation, and fishery compensation for any reasonable level of unavoidable loss

Task 1.4.8: Yakima River - Prosser Dam

The Bureau of Reclamation operates the Chandler power project, a low-head diversion dam (Prosser Dam) and canal, on the Yakima River. A conventional horizontal-axis rotating drum screens and associated fish bypass system is installed near the entrance of the power canal to prevent fish from reaching the powerhouse. Considering the maximum flows which can be diverted, the screens are undersized according to current fisheries agency screening criteria. The design of the downstream migrant bypass facility, and the design of the screen structure in relation to the bypass could be improved based on the many years of fish passage research results since this project was constructed.

No recent evaluation of the screening and bypass system has been conducted. The screening facilities are not causing any obvious losses of fish; however, water velocities approaching the screens do exceed criteria.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the continued operation and maintenance of the fish bypass facility at the Chandler project and provision for improvement of the facility should observations and/or study indicate ineffective operation, and fishery compensation for any reasonable level of unavoidable loss.

Subobjective 1.5: Maximize juvenile fish passage survival through mainstem reservoirs

Juvenile fish mortalities associated with power turbines and flows in the Columbia Basin power system have been discussed under subobjectives 1.1 and 1.3. A portion of mortality during outmigration of juvenile anadromous salmon, however, has been attributed to predation by fish (Bell et al. 1976, Raymond 1979). Predation losses are a basin-wide problem in the Columbia River and Snake River reservoirs, but the aggregations of predators in areas such as tailrace and river mouth areas are better known. While predation is a functional part of all large river ecosystems, the predator-prey relationships of the Columbia and Snake River reservoirs are highly modified from natural riverine conditions. The predator-prey relationshisps have been modified by: (1) changes in the available habitat and (2) changes in species structure and function of the fish community.

Task 1.5.1: Reduce predatory losses of juvenile salmon and steelhead migrating through Columbia and Snake River reservoirs.

The Columbia and Snake River reservoirs changed the natural riverine habitat to a series of reservoirs with reduced current velocities and turbidity. Changes in turbidity of the Columbia River and Snake River during the construction of dams are known to be correlated with sockeye runs two years later, suggesting the possibilities of increased predation in less turbid waters (Junge and Oakley 1966). Raymond (1979) concluded that additional mortality of smolts during low-flow years could be partially attributed to predation during the extended outmigration through reservoirs. Increased predation may result from habitat changes such as reduced turbidity and current velocity in reservoirs that alter predator-prey relationships evolved under original riverine conditions. Smolts adapt for outmigration under riverine conditions by changed during the parr-smolt transformation in behavior (McInerney 1964), buoyancy (Pinder and Eales 1969), body shape (Riddel and Leggett 1981), and coloration (Vanstone and Market 1968). Behavioral and morphological characteristics such as these are often adaptations to enhance predator avoidance under specific habitat conditions in which predator and prey evolved, in this case, the Columbia and Snake rivers, not reservoirs.

Reservoirs have resulted in new warmwater and coolwater habitats in the Columbia Basin i[illegible]ded by various species. Backwater and embayments of reservoirs now provide habitat where juvenile salmon are closely associated

with predacious resident (non-anadromous) fish (U.S. Fish and Wildlife Service 1980; Zimmerman and Rasmussen 1981). Numerous exotic warmwater fish have been introduced and utilize the reservoirs for all aspects of their life history. (Wydoski and Whitney 1979). Introduced warmwater fish include sunfish (Lepomis sp.) channel catfish (Ictalurus punctatus), crappie (Pomoxis sp.), and largemouth bass (Micropterus salmoides). Additional introductions of exotic coolwater species include smallmouth bass (Micropterus dolomieuei), yellow perch (perca flavescens), and walleye (Stizostedion vitreum). Coolwater fish generally prefer lower water temperature that the sunfish family (Centrarchidae) but warmer than the coldwater fish such as salmon and trout (Salmonidae). Introduction of the anadromous American shad (Alosa sapidissima) into the basin now provides abundant prey in late summer and early fall. Juvenile shad are available when water temperatures are near summer highs and juvenile anadromous salmon are at relatively low abundance, thereby providing forage for predators not available before the introduction.

The quality of juvenile anadromous salmon and trout have also changed from the original stocks. In 1965 hatcheries did not contribute to the total number of outmigrants passing the present location of Lower Granite Dam; however, by 1975, 75 percent of the juvenile chinook passing the dam were fish of hatchery origin (Raymond 1979). Juvenile fish of hatchery origin can be expected to have reduced suvival rates and growth potentials under natural conditions (McIntyre and Reisenbickler 1977; Reisenbickler and McIntyre 1977). Artificial selection in hatcheries can alter genetically controlled characteristics of the population. For example, the innate control of migration of sockeye salmon (Oncorhynchus nerka) fry from natal gravels to rearing areas can be altered by selection of brood stock (Raleigh 1971;

Raleigh and Chapman 1971). The cause for lack of success in re-establishing coho salmon (Oncorhynchus kisutch) in the mid-Columbia River is the lack of genetic suitability of the stocks used (Mullan 1980a). Greater mortality of hatchery smolts shortly after release at the first dams passed suggest planting loss is also substantial (Bell et al. 1976). Other problems caused by disease (Wedemeyer et al. 1980), water quality (Bouck 1977), and extended outmigration (Raymond 1968, 1979) of smolts of hatchery origin ultimately result in predation losses in reservoirs; however, in these cases predation results from changes in the quality of outmigrating juvenile salmonids not necessarily from more abundant or effective predators.

The predators of most concern in the Columbia Basin are squawfish (Ptychocheilus oregonensis) and walleye (Mullan 1980b). Squawfish predation has historically been a concern of fishery management agencies even before many of the reservoirs were created (Thompson 1959). The introduction of walleye, a voracious predator, occurred in the late 1940's in the upper Columbia River and their distribution has continued to spread. Changes in the fish community enhancing the predatory capabilities of species such as squawfish and walleye along with changes in the habitat from riverine to reservoir have permanently altered the original predator-prey relationships and are the cause of predation problems in reservoir passage.

Current Status: Predation problems in the Columbia Basin have been recently reviewed by Campbell (1979) and Mullan (1980b). Current research by the following investigators is underway and should add new information on the relative importance of predation mortality:

Bennett et al. Status of the warmwater fishery and the potential of improving warmwater fish habitat in the lower Snake River reservoirs. Idaho Cooperative Fishery Research Unit, University of Idaho.

Li et al. Habitat requirements for resident fishes in the reservoirs of the lower Columbia River. Oregon Cooperative Fishery Research Unit, Oregon State University.

Nelson et al. Population dynamics of fish populations in McNary Reservoir, Columbia River. Seattle National Fishery Research Center U.S. Fish and Wildlife Service.

Uremovich et al. Passage of juvenile salmonids through the icetrash sluiceway and squawfish predation at Bonneville Dam. Oregon Department of Fish and Wildlife.

Future direction and research priorities are being developed by the Predator Prey Research Committee (PPRC, an informal advisory group to the Columbia Basin Fishery Technical Committee).

A review of the current status of predation in the Columbia Basin reservoirs will emphasize squawfish and walleye, although predation by species such as channel catfish and smallmouth bass are potential problems in reservoir passage. The prey, juvenile anadromous salmon and trout, include a diversity of sizes ranging from small (50 mm) age 0 fall chinook (Oncorhynchus tshawytscha) to large (150 mm) spring outmigrating steelhead

(Salmo gairdneri) smolts. The temporal availability of these prey items is also very different, for example, steelhead smolts are most abundant during the spring outmigration while fall chinook have an extended summer residence time in reservoirs in the lower Columbia.

The study of squawfish predation on sockeye salmon (Foerster and Ricker 1942) revealed that predation on smolts was sufficient to substantially reduce adult returns. Squawfish feed mostly on insects, crayfish, and sculpins usually consuming one major food type in the free-flowing Willamette River (Buchanan et al. 1980). In John Day reservoir they feed mostly on sculpins (Li and Schreck 1981); however, their opportunistic feeding patterns on easy to capture prey items makes them an effective predator in areas of high smolt abundance, on smolts injured or disoriented during passage, or on less fit hatchery fish. Information on the daily rate of smolt consumption by squawfish is limited to rate of occurrence in stomachs although research currently underway or proposed may fill that information gap. Sims et al (1977) estimated squawfish populations in the upper one-half of Lower Monumental reservoir at 133,000 squawfish and found 21 percent of the stomachs contained salmonids. Estimates of smolt mortality where predation has been isolated as a cause are limited to one study at Ice Harbor Dam were 33 percent mortality occurred for smolts entering the back-roll from turbine discharge. Accurate estimates of daily rate of smolt consumption and squawfish populations are necessary to isolate squawfish predation from other predation and non-predation mortality.

The walleye is a predator with great potential for inflicting large predation losses on Columbia Basin juvenile anadromous fish. Walleye are well

adapted for temperate reservoir environments and they often assume a dominant position in their native lakes. Under natural conditions walleye predation has a depensatory effect on prey abundance, particulary weak year classes of yellow perch (Forney 1971). In natural systems walleye assume the "keystone predator" position (Paine 1966, Mullan 1980b) in the fish community and thereby suppress competition between prey populations by depressing prey abundance through predation. Although walleye were introduced in the upper Columbia Basin in the 1940's, they have only recently become abundant in John Day Reservoir (Hjort et al. 1980).

Additional changes in the fish community of the lower Columbia River can be expected as walleye become more abundant. For example, in F.D. Roosevelt Lake during 1949 squawfish composed 65.4 percent and walleye composed 0 percent of the species composition as measured by gill net while during 1980 squawfish composed 14.2 percent and walleye composed 30 percent (Harper et al. 1981). The development of walleye population and the fishery should be regarded with great caution, because a general lack of information on walleye and salmonid interactions exists.

Reduction of predator abundance is the most common approach to predation problems, but not the only (Campbell 1979). One of the most successful predator control programs is the control of sea lamprey in the Great Lakes. The re-establishment of lake trout (Salvelinus namaycush) and recovery of other fish stocks is evidence of the success of this program (Smith and Tibbles 1980). Other programs to reduce squawfish abundance have been effective in smaller lakes (Foerster and Ricker 1942; Jeppson and Platts 1959). The development of a selective fish toxicant (Squoxin) makes

this a potential control method for squawfish. Funds are badly needed to get Federal clearence of Squoxin. Reduction of predation can also be accomplished by reducing prey availability to the predators. Numerous managment alternatives for juvenile anadromous fish make this option a potentially promising one.

Additional research is necessary to better document predator-prey relationships and estimate the juvenile anadromous fish mortality due to predation during reservoir passage. The relative importance of this mortality must then be compared to other known sources of mortality to guide prioritization of mitigation efforts. If mortality due to predation is relatively significant, then management alternatives to reduce prey availability or predator populations must be actively pursued.

Potential management practices that could be pursued to reduce predation problems include improved flows and improved passage at dams that would reduce exposure of smolts to predatory populations. Additionally, the use of a predator control such as Squoxin in limited areas where prey and predators congregate could provide relief from squawfish whose populations have expanded due to the reservoir habitat. Other predator control methods may also require development.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program reseach to better estimate the relative contribution of predation mortality on migrating juvenile anadromous salmonids in the Columbia and Snake Rivers; and undertake necessary procedural and

scientific processes required to potentially allow the use of Squoxin for limited predatory control.

Task 1.5.2: Minimize deleterious aspects and enhance the benefits juvenile anadromous fish experience during rearing, extended out-migration, hold over, or residualism in mainstem Columbia and Snake River reservoirs

Introduction: During the outmigration period juvenile anadromous salmon reside in reservoirs for various lengths of time. The duration of time spent in reservoirs is partially determined by the life history of the stock or species. A variety of terms are used to describe varying lengths of residence in reservoirs. For example, most spring chinook outmigrants pass in one or two months during the spring outmigration period while age 0 fall chinook utilize reservoirs during spring and summer for "rearing." Juvenile salmonids which do not migrate may "hold over" until the next year and subsequently migrate to the ocean. Still others may become "residuals," completing their life history without migration to the ocean. The length of time the juveniles remain in the reservoir is determined by the life history of stock, physiological condition of juveniles, and the reservoir environment. The reservoir experience of the smolt is one factor determining the survival and its ultimate contribution to returning adults.

In determining survival rates, losses through various lengths of reservoirs are important, otherwise an unusually high turbine loss will be assigned (Bell et al. 1976). Turbine passage mortality ranging from 11 percent at McNary (Schoeneman et al. 1961) to 16 percent at a mid-Columbia

dam (Parametrix 1980) can be compared to total mortality within a reach including reservoirs and dams. During the first year of study on systems mortality in the mid-Columbia, estimates of mortality rates ranged from 17 percent to 25 percent per dam and reservoir reach above Priest Rapids (Chapman and McKenzie 1980). The difference between turbine mortality (11-16 percent) and mortality in a dam and reservoir reach (17-25 percent) can be attributed to a variety of causes associated with reservoirs. A review will examine some of the possible causes of mortality and potential benefits derived by juvenile salmonids during residence time in Columbia Basin reservoirs although physical, chemical, and biological characteristics of mid-Columbia and Snake River reservoirs vary substantially.

Current Status: A variety of mortality factors incurred by juvenile anadromous salmonids during their reservoir passage are found in the literature. Predation by fish in a habitat changed from riverine to a series of reservoirs has recently been reviewed (Campbell 1979; Mullan 1980) and is discussed in another task. Limnology problems such as heavy metals and water quality were reviewed by Bouck (1976) and are also discussed in another task. The substantial progress in solving the dissolved gas supersaturation problem (Ebel et al. 1975) has also been recently reviewed (Ficheisen et al. 1980; Weitkamp and Katz 1980).

Stranding of juvenile fish has been identified as a mortality factor in Bonneville Pool (Washington Department of Fisheries 1979) although it appears to be limited in McNary Pool (Zimmerman and Rasmussen 1981). Fish diseases, examin- in another task, have been identified as a problem in the Columbia Basin (Fryer and Picher 1974) since latent bacterial and viral

infections are probably activated by the stress of outmigration (Wedemeyer et al. 1980). The degree to which these factors affect mortality is largely determined by the duration of reservoir passage or length of residence by juvenile fish in the reservoir.

The duration of outmigration in the mid-Columbia (Parametri, Inc. 1980) and Snake River (Raymond 1979; Sims and Ossiander 1981) is strongly influenced by river flow. Raymond (1968) found that juvenile chinook salmon moved only one-third as fast through reservoirs as through free-flowing reaches of the river resulting in hold over; for example, in fall of 1973, a low-flow year, holdover juveniles were evident in Lower Monumental and John Day Pools. Few holdovers were found in 1974, a high-flow year (Bentley and Raymond 1968). Hold over may be explained by the delay of outmigration and exposure of juveniles to higher temperatures subsequently resulting in desmoltification and loss of migratory behavior. Zaugg et al. (1972) found the limiting temperature of parr-smolt transformation to be near 13°C. Migrational characteristics of juvenile fish originating in the mid-Columbia (Sims and Miller 1977) and Snake River (Raymond 1979; Sims and Ossiander 1981) indicate a large percentage of smolts are exposed to water temperature greater than 13°C. The mean date on which water temperature reached 13°C during the last 15 years (1966-1980) at Ice Harbor Dam is May 17, well within the spring outmigration period. A portion of the outmigrating fish can be expected to be at marginal temperatures for smoltification and if delayed will be exposed to subsequent higher water temperatures. Exposure to higher temperatures of extended outmigration or holdover results in increased predation due to high consumption rates by predators at those temperatures (Bell et al.. 1976; Young et al. 1980). The exposure to mortality factors

discussed above have a deleterious effect on survival; however, the value of rearing by juvenile anadromous fish is not so clearly defined.

Studies to determine the value of rearing anadromous salmonids in smaller reservoirs on tributaries of the Columbia River indicate mixed success. The success of coho salmon rearing in reservoirs of the Clakcamas River system and the failure of the runs produced above projects on the Deschutes was attributed to differences in fish, behavior, reservoir environments, and passage facilities (Korn et al. 1967). Reservoirs in the Willamette River Valley were evaluated and found to have good potential for rearing sockeye and spring chinook salmon. In contrast, it was concluded that Lake Merwin chemical and thermal properties were suitable for rearing coho but intensive predation precluded the use of Lake Merwin as a rearing area for coho salmon (Hamilton 1970). Brownlee Reservoir, on the upper Snake River, had a restricted area suitable for salmonids because of high epilimnion temperatures and low concentratons of dissolved oxygen (Durkin et al. 1970).

A review by Diamond and Pribble (1976) concluded that the lower Columbia River appears to be a good rearing area for juvenile salmon in spring and fall. This conclusion was based upon the spring and fall peaks in insects and zooplankton (Clark and Snyder 1970) and the observed consumption by juvenile chinook salmon (Craddock et al. 1976). Slightly elevated temperatures and abundant food contribute to the growth of age 0 fall and summer chinook rearing in reservoirs and may enhance size and survival.

The positive aspects of rearing during periods of abundant food should not be confused with the potential energetic problems involved with extended outmigration during spring runoff when food abundance is low. The increased energy expenditure associated with swimming in reservoirs rather than passive riverine drift, extended outmigration (Raymond 1979), and restricted food intake (Snyder 1980) may adversely affect survival. Brett and Glass (1973) concluded that large reservoirs increased the rate of energy expenditure of downstream migrant Fraser River sockeye by 45 percent.

Reservoir passage has potential benefits, but many negative aspects. The duration of residence in a reservoir is not necessarily a negative aspect. The reservoir environment is now the first form of natural selection juvenile salmonid fish of hatchery origin are exposed to. Hatchery selection has altered stock characteristics (Ayerst 1977, Utter 1980). The survival rates and growth potentials of fish of hatchery origin can be expected to be lower than wild fish (Reisenbickler and McIntyre 1977). Therefore, it is necessary to not only estimate mortality rates but also identify causes of mortality. Current research being conducted on the mainstem Columbia and Snake River reservoirs, as follows, will better define the rearing of juvenile anadromous fish:

Bennett et al. Status of the warmwater fishery and the potential of improving warmwater fish habitat in the lower Snake Reservoirs. Idaho Cooperative Fishery Research Unit, University of Idaho.

Li et al. Habitat requirements for resident fishes in the reservoirs

of the lower Columbia River. Oregon Cooperative Fishery Research Unit, Oregon State University.

Nelson et al. Population dynamics of fish populations in McNary Reservoir, Columbia River. Seattle National Fishery Research Center U.S. Fish and Wildlife Service.

Sims et al. Effects of flow on the migratory behavior and survival of juvenile fall and summer chinook salmon in John Day Reservoir.

Research Needs:

A. Identify specific causes of mortality and determine relative importance to total mortality incurred by juvenile anadromous fish during rearing and extended outmigration.

B. Determine the potential for rearing juvenile anadromous fishes in mainstem reservoirs of the Columbia Basin and utilize available resource for natural rearing.

C. Optimize survival of hatchery fish during reservoir passage by improving fitness and considering environmental problems of reservoir passage, but still minimize adverse effects on wild anadromous fish.

Products:

A. Products of research need A:

1. Mortality estimates of specific causes of mortality during extended outmigration or rearing by juvenile anadromous fish.

2. Identification of alternative management practices to minimize adverse effects of extended outmigration and holdover.

B. Products of research need B:

1. Identification of the life history, biological, and physical requirements of various stocks of juvenile anadromous fish for rearing in reservoirs.

2. Determination of the feasibility of augmenting current rearing production of juvenile fish with additional hatchery or wild fish.

3. If feasible, conduct pilot projects to evaluate rearing potential in mainstem reservoirs.

C. Products of research need C:

1. Identification of health or physiological characteristics of juvenile anadromous fishes of hatchery origin not compatiable with rearing or extended outmigration.

2. Identification of reservoir characteristics not compatible with life history or physiology of juvenile fishes of hatchery origin.

3. Identification of management alternatives to minimize adverse effects of increased rearinb by hatchery fish on wild fish currently rearing in reservoirs.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program research to determine the causes of juvenile salmonid mortality in mainstem reservoirs, the potential for rearing of anadromous salmonids in mainstem reservoirs, and improvement in the survival of hatchery produced fish in the mainstem reservoirs.

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Subobjective 1.6: Improve effectiveness of interim transportation of juvenile salmon and steelhead past hydroelectric facilities.

The collection and mass transportation of salmon Oncorhynchus sp. and steelhead Salmo gairdneri from the lower Snake and Columbia Rivers evolved as a response to dwindling populations of returning adults. Chinook salmon and steelhead runs in the Snake River began a serious downward trend in the late 1960's (Park 1980). The total run (i.e., catch plus escapement) of chinook salmon originating from the Snake River dropped from 120,000 adults in 1972 to 50,000 in 1974. Steelhead have similarly declined from 100,000 adults in 1972 to 20,000 in 1974 (Ebel 1980).

The major factor contributing to this decline can directly be attributed to the increased number of dams for power generation and headwater storage. Prior to the development of the dams, spring freshets were uncontrolled and smolts were flushed out to sea. The situation that now exists is basically a controlled river, so that in normal flow years all of the water and migrating fish may pass through turbines (Eicher 1981).

Travel time for seaward smolts is related to river velocity: the higher the water velocity, the faster the rate of fish migration (Raymond 1979). Impounding the river has reduced its velocity and increased the migration time. Dams now inundate over 630 km of the migratory route for those fish migrating from the Snake River (Ebel 1980). Raymond 1979, determined that the rate of migration, depending on river flow, ranged from 24 to 54 km/day through a free-flowing river and from 8 to 24 km/day through an impounded

river (Table 1). Predicted travel time from Lower Granite to The Dalles Dam at various flows is presented in Table 2. Using the above rates, it is easy to see that travel time of migration can easily be delayed to one month. With the delay comes increased mortality from predation and disease (Bell et al. 1976) along with residualism (Raymond et al. 1974).

Low flows can have a detrimental effect on survival during the outmigration. From 1973 to 1979, survival of yearling chinook salmon from the upper dam on the Snake River to The Dalles Dam averaged 22% and ranged from 2% (in 1977 low flow) to 40% during 1974. Steelhead survival during the same period averaged 19% and ranged from 1% in 1977 to 42% in 1975 (Table 3) (Sims 1981).

During high flows, water and many downstream migrant juveniles spill over the dams. Spill reduces juvenile turbine mortalities, but creates supersaturated levels of atmospheric gases, primarily nitrogen. This in turn produced high mortality rates that ranged from 40% to 95% during 1965-75 high flow periods (Chaney and Perry 1976).

Researchers estimate juvenile losses from all causes will average 15% - 20% at each dam (Chaney and Perry 1976). For example, losses of juveniles from passage through turbines at McNary Dam averaged 11% (Schoeneman et al. 1961). Juvenile migrants from the Snake River now have a series of 8 dams to traverse. As a scenario, using 15% mortality at each dam, the survival should be approximately 27% below Bonneville Dam. This total doesn't take into account mortality between dams so is a maximum survival

figure. By referring to Table 3, we see that actual survival between 1973 and 1979 to The Dalles Dam was lower in most years than the 27% figure.

HISTORY OF THE TRANSPORTATION PROGRAM

Even before adult populations started their downward trend it was evident that a problem existed on the Snake and Columbia Rivers. In 1965, NMFS scientists began preliminary work on a plan to collect migrating smolts at upper dams and transport the juveniles to safe release sites below Bonneville Dam. Transported smolts presently bypass as many as eight dams and their associated problem areas. The transportation of smolts was first studied at Ice Harbor Dam in 1968-70, then at Little Goose Dam 1971-73 and 1976-80, and Lower Granite Dam in 1975-80. It was expanded to include McNary Dam on the Columbia River in 1978-80. In 1981, the program changed from a research mode of operation formerly operated by NMFS, to a management operation through the Walla Walla District Corps of Engineers (NPW). The fishery agencies provide biological oversight while NPW operates and maintains the facilities and transport vehicles.

From 1968 to 1973, transportation of smolts from the Snake River was limited, with minor exceptions, to those fish tagged to evaluate the program. The main objectives of the research were to determine the effect of transportation on homing and survival of juvenile chinook salmon and steelhead collected at upper dams and released below Bonneville Dam. Early data on survival and homing from transportation showed positive results. By 1975, due to continuing high dam-related mortalities and positive data supporting the transport concept, the decision was made to haul all fish that

could be collected (Park 1980). This practice was begun in 1975 at Little Goose Dam, expanded to include Lower Granite in 1976, and McNary in 1979. Table 4 reflects increases in numbers of smolts hauled each year from 1971 on.

Since 1976, the transportation has accounted for more than 87% of steelhead and 75% of chinook salmon survival (Table 5) from the upper dam on the Snake River to below The Dalles Dam (Sims 1981). During the 1977 low-flow year, transportation accounted for almost 100% of the fish survival.

A summary of the percent of chinook salmon transported from and subsequently returning as adults to the Snake River along with transport benefit ratios for 1968 to 1978 are shown in Table 6 (Park 1980). Table 7 summarizes the same information for steelhead. Steelhead show relatively consistent transport benefit ratios and percent return of adults for all years except 1977. Early data on chinook returns showed positive transport benefit ratios and percent adult returns, but since 1976 the percent return has declined. The greatest transport benefit ratio for both species in the past has occurred during low-flow years (1973, 1977).

The first adults were recovered from groups of smolts transported from McNary Dam in 1978. The transport benefit ratios based on preliminary data are: 10:1 for fall chinook salmon, 2.3:1 for coho salmon, and a range of 1.9:1 to 4:1 for steelhead (Park 1980). These ratios can be used to compare relative success among years and between species but are of little value in determining the absolute survival of transported fish, since marked fish used

in these experiments suffer higher mortality migrating downstream than unmarked fish.

MODES OF TRANSPORTATION

Air Transport - In 1976, NMFS initiated a two-year study to determine if increased benefits could be obtained by air transportation. Shortened transport time and nearly unlimited release sites were positive points. This form of transport was discontinued due to the high cost when compared to adult fish returns.

Truck Transport - Trucks have long been the traditional mode of transporting live fish. Available literature on this subject is extensive. Problems associated with the transportation of fish were summarized in a series of articles by McFarland and Norris 1958 on the use of chemical buffers, McFarland 1960, on the use of anaesthetics, and Norris et al. 1960 on the general problem of fish transportation. This series of articles completely surveyed fish transportation technology in the early 1960's. Fish transportation today is based on essentially the same technology as was available fifteen years ago.

Truck transportation from collector dams has been used from the start of the program. It moves fish quickly and is the most economical transport mode for relatively small groups of fish. Steelhead have shown the best and most consistent transport benefit ratios and percent returns (Table 7). Chinook salmon benefits have varied from year to year, percent returns in recent years have been low (Table 6). Currently 3,500-gallon fish trailers

are used to haul smolts. With the present criterion at the transport dams of ½ pound of fish per gallon of water, 1,750 pounds of fish can be transported each trip.

Barge Transport - The present program utilizing barge transport began initially in 1977 when NMFS and the COE determined that insufficient numbers of trucks were available during the peak migration period. That year two barges were obtained, tested, and used. A third barge was obtained prior to the 1981 spring migration. The three barges hold 85,000 gallons of water with 5,200 gallon-per-minute (gpm) flow. With the present loading criterion of 5 pounds of fish per gpm and a maximum density of 0.5 pounds of fish per gallon, each barge will hold 26,000 pounds of fish with a 30% margin of safety. Preliminary marked adult returns of barged chinook indicate this method of transportation to be more beneficial than trucking. Barged adult steelhead returns have been comparable to trucked steelhead.

THE 1981 TRANSPORT PROGRAM

The 1981 transport activities at Lower Granite Dam, Little Goose Dam, and McNary Dam changed from a research mode of operation to a management type of operation. The NPW provided funding and manpower to operate the program while the fishery agencies provided biological oversight. The NMFS biologists provided training to State and NPW personnel for future management of the operation.

The Fish Transportation Oversight Team (FTOT) was formed to provide coordination between fishery agencies and NPW. FTOT was composed of a

NMFS Transportation Coordinator (Chairman and Program Manager), a COE fishery biologist representative, and an IDFG fishery biologist. Inspections were conducted by FTOT prior to and during the season to ensure facility readiness.

The transportation program could not be conducted on the scale it is today of submersible traveling screens (STS), bypass systems, and holding facilities had not been developed. Turbine units are screened with STS's and smolts are guided into the bypass system for delivery to the raceway holding facilities.

Major operational problems continue to be torn traveling screens and debris in the bypass and raceway holding facilities. To minimize those problems, periodic inspections are conducted at each dam.

The transport program is presently conducted so maximum numbers of migrating salmonids are collected and transported safely below Bonneville Dam for release. The mode of transportation incorportates trucks early and late in the season. Barge transport (3 barges) was used during the peak spring migration period with trucks filling in as needed. Round trip time for a barge from Lower Granite to the release site below Bonneville and back is approximately 96 hours. This allowed barge loading three of every four days during the peak migration period.

Sampling, handling, and marking were kept near 5 percent of the total fish collected at each facility. Stress areas to fish in the bypass collection facilities, and by handling, needs to be identified and methods developed to

correct problems. Studies are being conducted to isolate stressful areas and more research is planned in the future.

TRANSPORTATION IN THE FUTURE

A. Lower Snake and McNary Dam

Transportation has been regarded by the fishery agencies and tribes as an interim solution to downstream migrant passage losses until adequate bypass systems and flows are provided. At McNary Dam this is certainly the case and transportation may no longer be required once planned bypass systems are completed at downstream projects. In the lower Snake River, however, it is unlikely that the completion of bypass systems at Lower Monumental and Ice Harbor dams will sufficiently reduce mortalities to render transportation unnecessary, especially during low flow years. Spill is required at these two dams to provide interim protection to nontransported fish until adequate bypass systems are in place.

Losses in the lower Snake River are associated primarily with the effects of delay from the lack of adequate flows while the installation of bypass systems addresses only those losses associated directly with the project. Stored water necessary to provide flushing flows for fish is very limited in the upper Snake River requiring some level of transportation to be a part of future fish protection operations, especially in years when runoff is below normal.

This need for continuing transportation should not be construed as

agency and tribal acceptance of transportation as a substitute for adequate bypass systems. Transportation is to be regarded as only a supplement cannot be regarded as an acceptable alternative to either bypass systems or flows.

Since the ongoing transportation program in the Snake River (from Little Goose and Lower Granite dams) is vital to the maintenance of what is left of the once great runs of salmon and steelhead in that system, every effort must be made to improve the effectiveness of this technique. Many problems have been associated with this program. Minimal straying of transported fish has occurred but delayed mortality due to stress has been unacceptability high. As a consequence, adult returns have been disastrous. Survival for transported yearling chinook to returning adults for the last three years has been less than 0.5% while steelhead have survived somewhat better at 2 percent. This compares to an expected survival rate of 10 percent for fish that have not been impacted by dams. Yet even with these poor return rates, survival of transported fish is still superior to that of nontransported.

To make transportation work we must solve the problem of stress and continue to document straying. Stress has been identified as the primary factor affecting the survival of transported fish and many of the recommendations which follow address this area of concern. The potential problem of straying will need additional study also since transported fish from hatcheries have been found to have greater difficulty in returning to their stream of origin than non-transported fish. This is not surprising since imprinting cues are affected by the transportation process. A limited amount

of straying may be acceptable, and in some cases may benefit downstream fisheries so long as sufficient fish home successfully to provide needed spawning escapements and upriver fisheries.

B. Mid-Columbia

In the mid-Columbia where the PUD dams are located the primary source of loss is believed to be associated directly with the projects since needed flows can be (and have been) provided from upstream storage reservoirs. With the provision of adequate flows for downstream migrants and the installation of effective bypass systems a transportation program would be unnecessary. Transportation cannot be considered as an acceptable alternative to efficient bypass systems.

Because no PUD dam has an effective bypass system, interim spill is needed to improve survival it migrants at these projects.

C. Treaty Tribe Perspective on Transportation

Smolt transportation is viewed by the Columbia River Inter-tribal Fish Commission (CRITFC) as inconsistent with treaty obligations. The member tribes of CRITFC have a treaty right to the protection of natural anadromous fishery habitat; barge transportation is not protection of habitat. Modification of dam operations, improved flows and bypass facilities at Columbia River system dams are viewed as the preferred alternatives to barge and truck transportation. This is consistent the obligation of the federal water managers to operate the FCRPS projects so as not to impair or destroy tribal fishing rights.

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APPENDIX 1

List of Tables

Table 1--Migration rates (Km/day) of juvenile chinook salmon and steelhead through free-flowing and impounded sections of the Snake and Columbia Rivers for varying river flows. (Raymond 1979).

	Magnitude of Flow		
	Low[1/]	Moderate[2/]	High[3/]
Free Flowing	24	40	54
Impounded	8	13	24

1/ Snake, 1,000 to 1,500 M^3/second: Columbia, 4,000 to 5,000 M^3/second

2/ Snake, 2,000 to 3,000 M^3/second; Columbia, 6,000 to 9,000 M^3/second

3/ Snake, 3,000 to 5,000 M^3/second; Columbia, 10,000 to 14,000 M^3/second

Table 2.--Predicted travel time for yearling chinook salmon and steelhead smolts from Lower Granite Dam to The Dalles Dam, given various flow levels.[a/]

Flow(cfs x 1000)	Predicted travel time: Avg. per project (days)		Predicted travel time: Lower Granite to The Dalles Dam (days)	
	Chinook	Steelhead	Chinook	Steelhead
50	5.0	4.7	30	28
75	3.6	3.5	22	21
100	2.8	2.8	17	17
125	2.3	2.4	14	14
150	2.0	2.1	12	12
175	1.8	1.8	11	11

[a/] Avg. flow at Ice Harbor Dam during migration peak (± 7 days).

Table 3.--Survival of Snake River chinook salmon and steelhead smolts to The Dalles Dam and prevailing flow and spill, 1973-1979.

Species and year	Survival to The Dalles Dam(s) (%)	Survival per project $\sqrt[n]{s}$ (%)	Flow at Ice Harbor Dam (cfs x 1000)[a/]	Avg. spill per dam (cfs x 1000)
Chinook				
1973	5	55	71	8.6
1974	40	86	158	102.8
1975	25	79	140	102.8
1976	24	79	110	67.0
1977	2	52	40	2.0
1978	37	85	106	34.7
1979	24	79	85	8.3
Steelhead				
1973	5	55	68	9.5
1974	23	75	103	80.8
1975	42	87	136	102.3
1976	29	81	167	122.5
1977	1	46	40	1.0
1978	24	79	106	34.7
1979	12	70	89	10.6

[a/] Average flow at Ice Harbor Dam during the period ± 7 days from migration peak.

Table 4.--Number of chinook salmon and steelhead smolts and percent of total Snake River outmigration transported below Bonneville Dam 1971-1979 (includes experimental fish marked for transport evaluation).

Year	No. of turbine units screened	Chinook smolts: No. at upper dam (1,000)	Chinook smolts: No. hauled (1,000)	Chinook smolts: % hauled	Steelhead smolts: No. at upper dam (1,000)	Steelhead smolts: No. hauled (1,000)	Steelhead smolts: % hauled
Transport from Little Goose Dam							
1971	3	4,000	109	3	5,500	154	3
1972	3	5,000	360	7	2,500	227	9
1973	9[a/]	5,000	247	5	5,500	176	3
1974	0	3,500	0	0	5,000	0	0
Transport from Lower Granite and Little Goose Dams combined							
1975	9	4,000	414	10	3,200	549	17
1976	10	5,000	751	15	3,200	435	14
1977	15	2,000	1,365	68	1,400	895	64
1978	30	3,180	1,623	51	2,120	1,355	64
1979	33	4,270	2,109	49	2,550	1,712	67
1980	36	5,400	3,254	60	3,600	2,860	79

a/ Nine screens were used only until 11 May 1973 - thereafter, three were used for duration of the outmigration

Table 5.--Number of smolts transported from McNary Dam to Bonneville Dam, 1978-80. Numbers include experimental fish marked for transport evaluation.

Year	No. of units screened	Spring chinook (No.)	Summer/fall chinook (No.)	Coho (No.)	Sockeye (No.)	Steelhead (No.)
1978	1	32,000	40,000	22,000	7,000	24,000
1979	2	405,000	581,000	87,000	211,000	185,000
1980	2	380,000	1,060,000	33,000	50,000	210,000

Table 6.--Estimated number of steelhead smolts arriving at the upper Snake River dam and The Dalles Dam, 1973-79.

Year	Number of smolts (millions)			
	Upper Snake River dam[a]	The Dalles Dam	Transported	Total below The Dalles Dam
1973	5.5	0.2	0	0.2
1974	5.0	1.4	0	1.4
1975	3.2	1.1	0.6	1.7
1976	3.0	0.8	0.4	1.2
1977	1.4	0.01	0.9	0.9
1978	2.1	0.2	1.4	1.6
1979	2.6	0.15	1.7	1.8

[a] Little Goose Dam 1973-74, Lower Granite Dam 1975-79.

Table 7.--Estimated number of yearling chinook salmon smolts arriving at the upper Snake River dam and The Dalles Dam, 1973-79.

Year	Number of smolts (millions)			
	Upper Snake River dam[a]	The Dalles Dam	Transported	Total below The Dalles Dam
1973	5.0	0.3	-	0.3
1974	3.5	1.4	-	1.4
1975	4.0	0.9	0.4	1.3
1976	5.1	1.3	0.8	2.1
1977	2.0	0.01	1.4	1.4
1978	3.2	0.6	1.6	2.0
1979	4.2	0.5	2.1	2.6

[a] Little Goose Dam 1973-74, Lower Granite Dam 1975-79.

Table 7.--Percent adult return from transported chinook salmon smolts with benefit ratios (transported vs. control) and total adult return to the Snake River, 1969-79.

Year	Population at upper dam (million)	Percent return of transported smolts	Transport benefit ratio	Total adults returning from smolt outmigration[a/] (No.)
1968	2.5	9.00	3:1	104,000
1969	2.5	1.60	1.3:1	87,000
1970	5.4	0.90	1.5:1	162,000
1971	4.0	0.77	1.6:1	90,000
1972	5.0	0.11	1.1:1	41,000
1973	5.0	0.52	15.4:1	18,000
1974	3.5	No Transport Tests		43,000
1975	4.0	2.11	2.1:1	104,000
1976	5.0	0.14	1:1	25,000
1977	2.0	<0.10	∞:1[b/]	7,000
1978	3.2	0.11	5.2 to 7.7:1	19,000[c/]
1979	4.3	[d/]	[d/]	[d/]

a/ Ice Harbor escapement plus Columbia River harvest.

b/ No controls returned; therefore, a useful benefit ratio could not be established.

c/ Estimate based on 1- and 2- ocean returns to date.

d/ Only jacks have returned to date.

Table 8.--Percent adult return from transported steelhead smolts with benefit ratios (transported vs. control) and total adult return to the Snake River, 1971-79.

Year	Population at upper dam (million)	Percent adult return from transported smolts	Transport benefit ratio	Total adults returning from smolt outmigration (No.)
1971	5.0	1.4	1.7:1	74,000
1972	2.5	1.8	3.25:1	26,000
1973	3.8	2.7	13.4:1	12,000
1974	5.5	No Transport tests		23,000
1975	3.2	2.5	3.26:1	68,000
1976	3.2	2.1	1.5 to 5:1	60,000
1977	1.4	0.9	7.4 to 16.6:1	12,000
1978	2.1	2.2	3.8 to 4.1:1	43,000
1979	2.6	a/	3.5:1	a/

a/ Data insufficient at this time to estimate percent return or total adult return.

Task 1.6.1: Expand fish holding facilities at McNary, Little Goose, and Lower Granite Dams to improve the effectiveness of fish transportation.

The above three dams are major collection and transportation terminals. Holding facilities at these dams are inadequate for present and predicted future outmigrations. Uncrowded and less stressful holding conditions must be maintained to improve the survival of transported fish.

With Lower Snake Fish and Wildlife Compensation Plan hatcheries scheduled for increased fish production in 1983 and beyond, the need to expand holding ponds at each facility becomes apparent. An additional 26,932,000 compensation fish are scheduled for production and release in the near future. Compensation hatchery smolts should more than double the number of juvenile fish migrants at the Snake River projects. Numbers of fish transported by truck or barge in 1981 are listed: Lower Granite - 2.8 million, Little Goose - 1.5 million, and McNary - 4.2 million. Facilities should be designed to accommodate increasing numbers of smolts at collection projects.

Fingerling densities are currently 5 pounds of fish per gpm flow in the raceways. Uncrowded holding conditions should be maintained (0.5 pounds of fish per gallon) to provide less stressful holding conditions and improve the survival of transported fish. Hatchery fish should be more adaptive to raceway/pond holding conditions. Studies have indicated that hatchery

salmonids are more aggressive than wild stocks, particularly at the higher densities (Moyle 1969; Fenderson and Carpenter 1971; Bieber 1977). Therefore, higher holding densities may be more detrimental to wild stocks than to hatchery produced fish.

Design and expansion of current holding facilities at Lower Granite and Little Goose Dams are scheduled for a 1983/84 completion date. Although no design is completed at present, projected holding facilities are expected to have twice the holding capacity as the present system. Holding capacity for each Snake River collection facility is 6,000 pounds of fish per raceway (5) or 30,000 pounds total. Inflows are 1,200 gpm per raceway, with no greater than 5 pounds of fish per gpm being the loading factor. Doubling the capacity should enable the projects to keep the lower loading density of no more 5 pounds fish per gpm when the projected additional smolts arrive from the compensation hatcheries.

The McNary Dam juvenile facility should be relocated when the new second powerhouse is completed. The new facility tentatively should incorporate both the first and second powerhouse juvenile bypass systems into a more central location with better truck and barge access. The facility should increase the holding capacity to handle large numbers of fingerling outmigrants from the Snake and Columbia River at the lower loading rate of no more than 5 pounds fish per gpm of water flow.

Recommendation: The Northwest Power Planning Council adopt for inclusion in its Fish and Wildlife Program expanded fish holding facilities at Lower Granite, Little Goose, and McNary Dams to allow efficient transportation of

smolts and holding at densities of no greater than 5 pounds/gpm. Necessary work would be funded and constructed by the U.S. Army Corps of Engineers.

Task 1.6.2: Minimize fish injury and stress-related areas in the collection and transportation systems at Little Goose, Lower Granite, and McNary Dams.

Improved success in transportation of steelhead and improvements in chinook transportation are potentially attainable by careful testing and analysis of various portions of the collection, bypass, and transportation systems. Fish loading densities in the holding facilities and barges require study for maximizing survival.

A major objective of the fish transportation program is the safe collection and transport of fish from the collector dam to a release point below Bonneville Dam. Improving the total collection, holding and transfer of the migrating salmonids will ultimately establish a more successful fish transport program.

Research is needed to test for weak links in the transport program. Areas of research are:

1. Indexing - Cataloging estimated collection efficiencies with numbers of fish arriving at the dams during various flow patterns.

2. Stress - There is strong evidence from the literature (Schreck 1970) that it stresses are imposed on juvenile salmon, the ability to osmoregulate is severely reduced and hence mortality occurs. Pinpointing specific stress

areas in the collection and transport process is needed. Research to determine stress may include saltwater challenge and blood chemistry tests. Determining high stress areas in the system and correcting the problems should result in fish which can better adapt to saltwater, disease, and stresses after their release from the collector projects.

3. Fish guiding devices - Currently, submersible traveling screens are being used to divert fish into the gatewells where they egress into a bypass system to the holding facility. Fish guiding efficiency of traveling screens should be determined using different turbine load conditions. Knowing fish guiding efficiencies should give managers at the dam an estimate of fish populations arriving at the collector project.

4. Holding and transport densities - The density in raceway/ponds and transport vehicles is currently 5 pounds of fish per gpm flow or ½ pound fish per gallon of water. Research to determine the best holding and transport densities is needed to optimize smolt survivals. The optimum holding density will determine numbers of transport vehicles necessary to haul the fish as well as numbers of ponds/raceways when compensation hatcheries come on line.

5. Transportation evaluation - Adult returns should be monitored yearly to evaluate the transport program. This may require marking juvenile salmonids at the collector facilities or the hatcheries.

6. Direct transport from hatcheries - Possible benefits include increasing adult returns, reducing number of fish at collector dams, and fish

transported in better condition than those migrants that are collected after encountering a dam. Increased survival will occur by direct transportation, but research is needed to determine if adults will return to the hatchery or origin (homing).

Recommendation: The Northwest Power Planning Council adopt for inclusion in its Fish and Wildlife Program, research programs geared to improving the success of transport operations at Lower Granite, Little Goose, and McNary Dams. Necessary work should be funded by the U.S. Army Corps of Engineers or the Bonneville Power Administration.

Task 1.6.3: Modify fish holding facilities at Little Goose Dam to reduce fish injury and mortality.

The holding facilities are of inadequate design and are causing injuries and stressed conditions. Improvements are required for improved survival. The holding facilities at Little Goose Dam lack one important feature included at the other collector projects which is the ability to load trucks by a gravity feed system. Presently the raceways are not situated with sufficient head elevation to load transport trucks by gravity. Loading is accomplished via a 350-gallon truck loading hopper which is raised to an elevation suitable for loading. This loading process requires workers to be present on the truck and hopper lifing elevators during the loading procedures. Not only is there extra manpower involved, but also fish are crowded into the truck loading hoppers prior to loading the transport vehicle. The present method of loading trucks is an additional stress to smolts.

To remedy the situation, the existing upwell/raceways should be elevated to provide the necessary head for gravity loading. Raising the raceways serves another function, i.e., it will reduce head in the transport pipe and slow the water velocity in the pipe. This change should be planned in accordance with Task 1.6.1 which would be to increase or expand the fish holding capacity at Little Goose Dam. The fingerling system should be elevated and expanded to enhance fingerling holding and loading capabilities. The modification should result in a better quality fish collected and transported from Little Goose Project.

Recommendation: The Northwest Power Planning Council adopt for inclusion in its Fish and Wildlife Program the modification of fish holding facilities at Little Goose Dam, to reduce fish injury and stress. Necessary work should be funded and constructed by the U.S. Army Corps of Engineers.

Task 1.6.4: Monitor homing behavior of fish transported from dams and hatcheries for continued evaluation and improvement of transportation.

The phenomenon of specific homing of Pacific salmon, Oncorhynchus sp. and steelhead, Salmo gairdneri, to their natal stream is a documented fact (Taft and Shapovelov, 1938), but the specific mechanism(s) that cause a fish to "home" remain somewhat a mystery. A smolted fish emigrates from his stream of residence and through some process of learning (imprinting) is able to return to the same stream after residing in the ocean from 1-4 years.

Hatchery raised fish react no differently from the wild smolts, i.e., when released into a source of water, they generally return to that particular water source with little or no straying. It is a common hatchery practice to transport large numbers of salmonid smolts from hatcheries to satellite planting sites to where the adults home after their return from saltwater (Vreeland et al., 1975). Therefore, hatcheries can "seed" or plant fish into streams and have adults return to the stream planted rather than the hatchery of origin.

Transportation of actively migrating salmonids from Snake River dams was initiated due to dam-related mortalities and declining fish runs. Upon collection, smolts or juveniles were placed into trucks, or more recently fish barges, and transported to release sites below Bonneville Dam about 300 miles distance. Since transport research began in 1968, efforts have been made to quantify the degree of straying of transported fish. From transport studies at Ice Harbor Dam in 1968-70, straying of transported chinook salmon and steelhead was virtually unknown (Ebel, et al., 1973; Ebel, 1980; and Slatick et al., 1975). In later studies at Little Goose Dam (Ebel, 1980) some straying of chinook salmon was noted; however, in the instance noted, both transported and non-transported fish were recovered in the Deschutes River (Oregon) and overall straying could not be quantified. In more recent studies at Lower Granite Dam, straying of fish transported from dams may account for 1 - 2 percent of the adult returns (Park, et al. 1979). In general, straying of fish following transport from dams is not a problem.

Direct transportation of fish from hatcheries was deemed a possible alternative to releasing fish at upriver hatcheries and sustaining high predator and dam-related mortalities. The problem to be solved was: will the fish transported from hatcheries return to the release site or to the hatchery or origin?

From 1978 to 1980 the National Marine Fisheries Service has undertaken a series of homing tests whereby various stocks of Columbia River coho salmon, fall and spring chinook salmon, and steelhead have been given various treatments prior to translocation from hatcheries by truck or barge to release sites below Bonneville Dam (Slatick, et al., 1979, 80, and 81; and Bjornn, et al., 1980).

Slatick, et al., 1981, indicated that direct transport of steelhead in 1978 from the Wells-Winthrop and Chelan-Leavenworth hatcheries was unsuccessful in returning adults to the intended hatchery. An example of the homing loss from the Chelan-Leavenworth experiment, the tests on 1978 steelhead smolts, follows using test-to-control ratios at different evaluation points of their adult return migration. The test-to-control ratios were: 2.66:1 at Bonneville Dam, 1.34:1 at McNary Dam and .15:1 at Priest Rapids Dam. Adult test returns indicate a positive survival rate to the lower river (Bonneville Dam) and to sport/commercial fishermen, but show poor returns above Priest Rapids Dam and to Chelan Hatchery. All data point to straying being the problem which caused the poor returns to the hatchery rack.

An additional example of the effects of transportation on homing has been demonstrated with steelhead from Dworshak Hatchery that were translocated as smolts directly by barge in 1978 (Slatick, 1981). More barged fish were avilable to lower river fishermen, upriver sport fisheries, and to Dworshak Hatchery spawning than were comparable controls released at the hatchery. Test-to-control adult return ratios for various evaluation points of the fish are listed: 7.13:1 at Bonneville Dam/commercial harvest (Indian), 2.41:1 at McNary Dam, 1.59:1 at Lower Granite Dam, 1.73:1 Clearwater River sport fishery, and 1.63:1 at Dworshak National Fish Hatchery, the intended homing site. Again, the greater survival of the direct transported fish is evident as noted by the 7 to 1 recoveries in the lower river. However, the

decreasing proportion of transported fish higher in the river system indicates a significant potential for straying of upriver fish into lower river areas.

As a general overview, homing studies from upriver hatcheries indicate increased survival of the transported (test) fish compared to the control fish. The majority of the homing reports also, however, demonstrate considerable straying may occur.

Before transportation directly from hatcheries can be adopted as an annual operation to reduce hydroelectric projected-related mortalities, the success of homing must be determined. The effects of potentially large numbers of upriver strays on lower river populations must be adequately assessed.

Recommendation: The Power Planning Council adopt for inclusion in its Fish and Wildife Program a continued monitoring of adult returns from transportation studies to determine extent of straying of transported fish. Necessary work should be funded by the U.S. Army Corps of Engineers or the Bonneville Power Administration.

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Subobjective 1.7: Assure operation of existing and future thermal and hydropower plants will not infringe upon required water quantity and quality for smolts in the Columbia Basin.

A considerable amount of future energy reserve may be supplied by thermal plants located within the basin, particularly in the Hanford area. At Hanford, the Washington Public Power Supply System (WPPSS) has initiated construction of three reactors. Current planning for Skagit Nuclear Projects 1 and 2 is centered on evaluating potential sites in the Hanford Reach (pers. comm. Grant Bailey). The Department of Energy's (DOE) N-Reactor may soon be converted from fuel-grade plutonium production to making weapons-grade quantities of the material. The reactor is expected to operate at least into the early 1990's (pers. comm. Frank Standerfer). If political opposition to project construction in Oregon prevails, the proposed Pebble Springs projects could potentially be relocated to Hanford as well. It has been suggested that as many as 22 nuclear projects could be sited on the Hanford Nuclear Reservation (Snyder, 1968).

Future plant cooling through the use of cooling towers should decrease the total quantity of heated effluent discharged into receiving waters. However, water withdrawal for cooling tower operations could impact instream flows. Discharge of blowdown effluent, if not properly diffused could create water quality problems harmful to anadromous fish resources. Water quality and quantity through the Hanford Reach and other basin waters must be protected to maintain suitable protection habitat. In addition to providing

natural anadromous fish production habitat, the Hanford Reach is the sole natural passageway used by upper Columbia migrants both during their upstream and downstream migrations. Water quality criteria favorable to fishery resources must be maintained at all times at this and other migration routes. Strict compliance with water quality criteria to protect anadromous fishery resources must be a condition of project construction and operation. The water quality requirements of migrating smolts must be considered during planning, construction, and operation of thermal and hydroelectric resources. With good water quality and proper management practices, an appreciable fishery providing benefits to sport, commercial, and Indian fishermen can be maintained.

Water Quality Problems

A. Nitrogen Supersaturation

Nitrogen supersaturation of river water caused by spilling at dams contributes to losses of smolts. Losses have been related to the condition of the fish, the level of supersaturation, the depth at which fish were migrating and the duration of exposure (Ebel, 1977). A partial solution to this problem has been the addition of spillway deflectors at specific projects on the Columbia and Snake Rivers. These deflectors are concrete sills constructed near the base of the spillway to direct flow horizontally into the spilling basin. The lateral deflection of water reduces deep plunging action where air entrainment occurs. Spillway deflectors have been installed at all lower Snake River projects and at Bonneville and McNary Dams, and are believed to be the most

promising method of reducing gas supersaturation at this time. Unfortunately even with the installation of deflectors and maximum use of turbine capacities, dissolved gas levels during high flow years still continue to cause problems for migrants. This year saturation levels as high as 120-130 percent were measured as far downriver as the National Marine Fisheries Service Prescott Field Station (pers. comm. Charles Koski).

Several conclusions regarding the effects of supersaturation if atmospheric gas (gas bubble disease) on fish in the Columbia have been made from laboratory and field data (Ebel, et al., 1975). Some of the main conclusions reached were:

1. Nitrogen supersaturation has exceeded 130 percent over long stretches of the Columbia River during several years since 1968.

2. Juvenile and adult salmonids confined to shallow water depths (1 meter) suffered substantial mortality at 115 percent saturation after 25 days exposure.

3. Juvenile or adult salmonids allowed the option to sound and obtain hydrostatic compensation still suffered substantial mortaltity when saturation level exceeded 120 percent after more than 20 days exposure.

4. Juvenile salmonids subjected to sub-lethal periods of exposure can recover when returned to normally-saturated water, but adults do

not and generally die from the harmbul effects of the exposure to N_2 supersaturation.

It is anticipated that the completion and operation of additional turbine units at mid-and upper-Columbia projects during high flow years will reduce but not completely solve N_2 gas supersaturation problems.

B. Water Temperature

The significance of water temperatures to aquatic life is better understood if it is remembered that fish are cold-blooded. They depend on their environment to provide a suitable temperature range to allow normal life functions without internal bodily regulation. Water temperature is probably the most dominant factor controlling the behavior and activities of cold-blooded aquatic animals.

Temperature influences dissolved oxygen and nitrogen levels in water, disease incidence, susceptibility to predation, and directly affects a fish's ability to migrate, spawn, and develop.

In the evolution of the species, Columbia River Pacific salmon and steelhead trout have adapted their life activities to the naturally occurring conditions in the Columbia Basin. River flow and water quality characteristics of the Columbia and its tributaries have become environmental requirements for particular species and races.

Concern for water temperature in the Columbia River has existed for some time. The Columbia River Thermal Effects Study (CRTES) (Anon., 1971) was initiated to address inconsistency in water temperature standards for the Columbia which had been adopted by the States of Oregon and Washington. In the report, optimum temperature ranges conducive to the production of fish resources in the Columbia were recommended by cooperating fishery agencies. The recommendations were as follows: Migration routes 45° to 60°F, spawning areas 45° to 55°F, and in rearing areas 45° to 60°F. The CRTES also included research on the thermal tolerance of juvenile salmonids, including the biological effects of passage through thermal plumes at Hanford. At that time, and even today, few researchers have been allowed to study the DOE facility thermal plumes and none have had access to classified information concerning the 112°F effluent temperatures or plume mixing characteristics. The study concluded that losses of smolts due to passage of thermal plumes at Hanford were probably small. However, under certain environmental conditions such as low river flow and high water temperature, the potential for lethal exposure to juvenile migrants clearly exists. Presently, the WPPSS Hanford Generating Project and the DOE N-Reactor are the only two facilities discharging large volumes of heated effluent at Hanford. Although some study has been performed on the Hanford Generating Project (HGP) plume, sound biological data on smolt losses due to the plume do not exist. At this time, WPPSS and fishery and regulatory agencies are working to reduce smolt losses at HGP through coordinating planning related to the installation of a new diffusor. However, no such facility is planned for DOE's N-Reactor.

Thermal shock can occur when migrants are exposed to high water temperatures. Whether exposure is lethal or non-lethal depends on species tolerance which has been related to acclimation temperature (Anon., 1971). The CRTES states that the ultimate upper incipient lethal temperature for juvenile salmon is apparently between 73.4° and 77°F if other stresses are minimal. However, it is known that many juvenile anadromous fish undergo tremendous stresses while passing through turbines and over spillways before reaching Hanford. Some stocks must encounter as many as five dams. The relation of thes stresses to the upper lethal temperatures given is not know. When thermal shock occurs, locomotor acitvity becomes disorganized and the fish loses its ability to escape from conditions that will soon cause its death. Some studies indicate that as many as 85 to 100 percent of chinook juveniles which lost equilibrium because of thermal shock died when returned to non-lethal temperatures (Dean and Contant, 1968; Snyder and Blahm, 1970). Other researchers have stated that once equilibrium loss occurs, the fish is "ecologically dead" through predation. Therefore, a thermal dose which induces equilibrium loss is probably just as important as one causing death (Stauffer, 1980). Equilibrium-loss temperatures have been shown to be consistently a few degrees lower than corresponding death temperatures (Young and Apts., 1977).

Sub-lethal Effects:

Since temp[illegible]ure has a major effect on metabolic rates of fish, and adult migrants eat very little if any during their upstream spawning

run, increases in water temperature may indirectly reduce future anadromous fish production. Added metabolic drain of these fish reduces available energy reserves needed to complete the spawning cycle. Besides increased body weight loss and reduced eating quality, additional metabolic wear and tear due to exposre to higher water temperature may adversely affect primary sexual development. Bouck et al. (1975) conducted studies on the effects of holding temperatures on reproductive development of sockeye salmon. Tests showed that a water temperature rise of 10°C to 16.5°C increased metabolic demand by as much as 155 percent. Higher water temperature was also associated with advanced development of secondary sexual characteristics and diminised development of gonads. Female test fish bore similar numbers of eggs but the average weight of the eggs was about 11 percent less than that of controls. While statistical analyses did not indicate a significant difference between test fish. The resultant impact on the progeny of test fish may be adversely affected as well. Additional study is required to determine the extent of sub-lethal effects of temperature on sexual reproduction.

Juvenile salmon and steelhead have shown difficulty in making the parr-smolt transformation when living at or above 55°F (Bouck, 1977). When water temperatures exceed 55°F, the fish grew well and appeared to be normal, but did not subsequently adjust to living in salt water. This finding has important significance to Columbia and Snake river salmon and steelhead because temperatures generally exceed 66°F as early as mid-May (Anon. 1965-75). The downstream migration of smolts

occurs between March and August and this may have a considerable adverse effect on resultant salmonid populations.

Incidence of Disease:

Studies have shown that sub-lethal water temperatures can also promote lethal infections by pathogenic organisms (Fryer and Pilcher, 1974; Becker and Fujihara, 1978). Columnaris is a bacterial disease of fish which can occur with high water temperatures and incresed physiological stress. Mortalities can occur before water temperatures reach 65°F. The bacterial pathogen, Flexibacter columnaris is known to be present in the basin. When high water temperatures occur, the disease spread can be accelerated. Becker and Fujihara studied the epizootiology of the pathogen among Columbia River fish. Their review of research data from studies conducted at Pacific Northwest laboratories from 1965-76 clearly indicates that pathogenesis of Columnaris is modified by water temperature, that the impact on fish populations is related to virulence, and that high virulence strains of the pathogen are now wide-spread among Columbia River fish. Their review did not indicate that operation of plutonium reactors at Hanford from 1944-1970 contributed significantly to the epizootiology of the disease. Instead, the spread of the disease was attributed to environmental modifications associated with hydroelectric development over the last thirty years. These modifications have resulted in transformation of the river into a near consecutive series of dams and impoundments. Future outbreaks of the disease may be influenced by low river flow and resulting temperature increases.

Another example of the water temperature-disease relationship is shown by infection by Ceratomyxa shasta. The disease is associated with salmonids and water from impoundments, such as fish hatcheries. The threshold temperature for initiating infection is approximately 50°F. The disease appears to be most virulent when water temperatures approach 65°F. Once the infection develops, death is hastened by increased temperature and infected adults may die before they can spawn (Fryer and Pilcher, 1974). At the present time, the diseases occur in certain stocks of fish which migrate upstream during the time of the year when water temperatures exceed 60°F. Other populations of fish could be exposed to lethal diseases if waste heated effluent discharge is permitted in quantities that could increase river temperatures above 60°F during fall, winter, and spring (Snyder, 1968).

Migration Blockage:

Probably the most common indirect effect of heat on fish in the Pacific Northwest is the delay of upstream migrations caused by water temperature blocks. These blocks can be produced by either natural or man-caused environmental conditions. Temperature blocks of sockeye salmon in the Okanogan River have been described by Major and Mighell, and by Moran at the confluence of the Snake and Columbia rivers. Migration delay was attributed to tributary water temperatures of near 70°F. A delay of sockeye salmon upstream migration of only five days caused significant mortalities in the Fraser River, British Columbia. Practically none of the fish were found to reach the spawning grounds when subjected to delays of 10-12 days (Snyder, 1968).

C. Other Potential Problems

The water quality of receiving waters can be adversely affected through the addition of cooling tower blowdown effluents. Cooling towers do not recirculate all the water required for their operation. The portion that is discharged is known as "blowdown." Depending on existing water quality at the site, chemicals must routinely be added to cooling tower make-up water to prevent fouling of condenser tubes. The thermal efficiency of the stream cycle can be greatly reduced if biological growth occurs in the condensers.

Major pollutants detected in waste waters of stream electric plants during an Environmental Protection Agency sampling program were total residual chlorine (TRC), copper, zinc, chromium, arsenic, and selenium. These pollutants, especially TRC, are toxic to fish and other aquatic organisms. Chlorine is also added to inhibit biological growth in cooling towers and condensers. Dechlorination, a chemical treatment that removes a significant amount of TRC before it is discharged, reduces TRC levels. However, it does not eliminate it (Federal Register, June 30, 1981). Recent research on the chlorine tolerance limits of 15 species of fish and invertebrates was performed by Battelle Laboratories (Thatcher, 1977-78). Ninety-six hour lethal concentration values (LC50) found were 0.032 mg/1 for juvenile coho salmon, greater than 0.038 and less than 0.065 mg/1 for juvenile chinook salmon. Another study, on the toxicity of intermittent chlorination to freshwater fish, simulated conditions often encountered in the outfall of steam electric generating plants which chlorinate intermittently. Fingerling steelhead trout and

coho salmon were used in tests. Differential toxicity was found between tests of free chlorine or monochloramine w=(Heath, 1977). The author recommended that water quality criteria for fish protection take the differential toxicity of chlorine form into consideration.

Recommendation: That the Power Planning Council include as part of its Fish and Wildlife Program support for ongoing biological and chemical monitoring of water quality in the Columbia Basin to assure energy development does not impair fishery standards. Programmatic support for water quality emergency planning and preparedness by appropriate tribal governments and state agencies should also be included.

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CHAPTER 2

OBJECTIVE II:

Adult Migrant Survival

CHAPTER 2

OBJECTIVE II: ADULT MIGRANT SURVIVAL

Many factors may influence the success of adult migrations of salmon and steelhead in the Columbia and Snake rivers including flows through reservoirs, water temperature, turbidity, and release of polluting effluents into the rivers. However, the most severe problems are associated with flows and currents immediately below the mainstem dams that influence passage into the fishway facilities. Although fishways have a recorded history of almost 300 years, many of the problems associated with getting salmon and steelhead safely past eight or nine projects on the Columbia and Snake rivers are unique. Such migrants must satisfy budgets of both time and stored energy if they are to survive to reach their spawning area and spawn successfully. Consequently, delay and wastage of energy are more deadly than turbine blades to many migrants, since each project presents many time and energy-consuming situations.

Those unfamiliar with the operations of fishways at mainstem dams may visualize them as vacuum sweepers or magnets that attract the migrants directly to the fishway entrances. If fishway flows competed with no other misleading attractions, such a conception might be reasonable since the instinctive behavior of such adult migrants is to swim upstream against the prevailing current. However, Columbia River fishways may be competing with flows of more than 300,000 cfs through the powerhouse and an additional 200,000 cfs over the spillway. Although the quantity of water used for fishway attraction is significant, it represents a very small percentage of the total river flow and must be used judiciously if fishways are to be adequately efficient.

During extremely heavy spills, it is possible to adjust the flow across the spill gates in a manner which will help to guide most of the fish approaching the spillway toward the fishway entrances located on either side of the spillway. To accomplish this, spilling schedules have been prepared and are followed at all Corps of Engineers dams on the Snake and Columbia rivers. Development of such schedules are needed for the mid-Columbia public utility district dams.

Because of the turbulence of the turbine discharge, major fishways adjacent to the powerhouse are frequently not as efficient. Studies involving analysis of fish counts, use of conventional and radio-tagged fish and installation of electronic tag detection tunnels in fishway entrances have given some insight into the problems. It has been demonstrated (Junge, 1971) that major changes in flow through powerhouses can interrupt fish movement. Losses in passing some dams have been particularly severe. Losses at John Day dam of 20 percent occur year after year (Gibson, et al., 1979).

Although immediate losses at some dams may not be great, the combined effects of delay at a sequence of dams has been demonstrated (Junge and Carnegie, 1976). Hirose (1980) shows the dramatic reduction in recent years of spawners in Snake River tributaries and although most of this is attributable losses of juvenile downstream migrants, a very significant portion is due to adult mortalities.

A primary complicating factor for adult passage at hydroelectric dams is the peaking mode of operation. The term, "peaking operations," refers to the fluctuation of power output in response to a fluctuating demand or a fluctuating supply capability. Under this definition, periods of reduce output as well as periods of increased output are both included as part of the peaking operation.

For the last several years fisheries agencies responsible for resolving fish passage problems at hydroelectric dams on the Columbia and Snake rivers have been concerned about the peaking operations being practiced as a result of development of upstream storage including completion of the reservoir storage projects in Canada, the installation of full complements of turbines at other Columbia and Snake River dams, and the construction of additional powerhouses at Rock Island and Bonneville dams. Peaking operations have adversely influenced upstream migrants for many years and have induced serious delay and mortality at some dams (see Literature Cited).

Adult mortality rates as high as 26 percent have been estimated at lower Columbia dams from 1973 to 1978 by the Oregon Department of Fish and Wildlife (Gibson, et al., 1979) as noted below.

Year	Season	Dam	Mortality %
1973	Summer	Bonneville	26
1973	Fall	Bonneville	21
1974	Spring	Bonneville	20
1974	Summer	Bonneville	24
1975	Summer	John Day	19
1976	Summer	Bonneville	22
1977	Spring	Bonneville	5
1977	Summer	Bonneville	4
1978	Summer	Bonneville	12

Those fish successfully passing the dams suffer migration delays. The average length of time of the delay at a project can vary from a matter of hours to several days and results in additional opportunity for stress and injury. The following table summarizes delays to Chinook salmon at lower Columbia River dams as determined by Oregon Department of Fish and Wildlife From 1973 to 1978 (Gibson, et al., 1979).

Peaking operations at dams are carried out by manipulating flows over the spillways or through the power units, resulting in fluctuations in the forebay and tailwater elevations and fluctuations in the total flow past the dam, or at least shifting of the distribution of that flow between the spillway and the various units of the powerhouse. These fluctuations result in changes in the velocity vectors in the vicinity of dam as well as through the reservoir, thus affecting fish migratory responses.

Although the effects of such fluctuations on adult upstream migrants are not well understood, there are a number of possible sources of delay to be considered. The path used by fish approaching a project and the efficiency of passage through fishway entrances will be influenced by fluctuations in tailwater elevation and turbine discharge. At many projects turbulence below the powerhouse during periods of peaking when the amount of water through the units is maxi ed can adversely affect passage since it obstructs the approach to the main fishway entrances (USCE, 1978).

Delay in Days to Chinook Salmon Due to
Lower Columbia River Dams During 1973-78

Location-- Date	Spring Chinook	Summer Chinook	Fall Chinook
Bonneville Dam			
1973	-	2.5	1.0
1974	4.0	2.5	-
1976	3.5	-	-
1977	1.0	2.0	-
1978	2.0	2.5	-
The Dalles Dam			
1973	-	1.0	1.0
1974	1.5	1.5	-
1976	2.0	-	-
1977	1.5	0.5	-
1978	1.5	2.5	-
John Day Dam			
1973	-	2.0	-
1974	3.0	-	-
1975	-	1.5	-
McNary Dam			
1975	-	2.0	-

For purposes of discussion, adult passage problems can be separated into (1) problems resulting from flow conditions in the river below and above the projects and in the immedate tailrace area at the base of the dam caused by specific project operations, which tend to discourage inriver fish movement or mask fishway entrance flows, and (2) problems resulting from inadequacies of fishway entrance design, entrance flow quantities, and design or operation of collection channels, fish ladders, counting stations or other fish facilities at or within the dam itself. The following subobjectives 2.1 and 2.2 attempt to discuss in more detail these two general areas.

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Subobjective 2.1: Provide optimal flow and spill conditions for adult migrants at each hydroelectric facility

Adult fishways are most effective when river discharge and distribution of flows over the spillway and through the powerhouse provide optimum mitigation conditions below the project to allow maximum attraction of upstream migrating fish into the fish ladder entrances. Considerable research on spill configurations for effective fish passage at the Corps of Engineers mainstem dams has been completed. Minimum instantaneous flows necessary for optimal passage are being investigated. The National Marine Fisheries Service, under contract to the Corps of Engineers, studied the effects of reduced flows at Little Goose and Lower Granite Dams on adult passage during 1981. The study results have yet to be finalized. Complete project operational guidelines need to be developed and adopted to maximize adult passage. The development of sound guidelines can require radio tracking of adult fish to examine their migrational behavior and varying project operating conditions as well as various methods of counting the movement of fish into and through fishways (USCE, 1974). Results of behavior studies would then lead to operational and/or structural modifications as necessary at the dam. Complimentarily or alternatively, hydraulic modeling can provide important data upon which to base guidelines. Guidelines developed must be adopted by project operators as part of project operating standards.

Task 2.1.1: Develop and institute spill configuration guidelines at each hydroelectric facility on the mid-Columbia River

From 1967 through 1977 the Oregon Department of Fish and Wildlife developed spilling schedules for all mainstem Corps of Engineers dams of the Columbia River system below Hells Canyon Dam. Included in this work was a detailed analysis of guidelines (Junge and Carnegie, 1972) for developing such schedules. Hydraulic models of all Corps of Engineer dams permitted detailed studies of flow patterns under varying spill and powerhouse schedules. These studies in conjunction with prototype studies confirmed the validity of the principles developed in the guidelines. (Junge and Carnegie, 1972).

Such detailed studies have not been conducted for the public utility district dams on the mid-Columbia River although Lehman and Paulik (1966) studied effects of spill on fish passage at Rock Island Dam which has been greatly altered since that time with construction of a new powerhouse.

Additionally, some of the Corps of Engineers dams on the mainstem Columbia and Snake rivers have been expanded and all are now operated more to provide peaking, rather than base load power which was originally studied. Therefore, the original flow and spill schedules for Corps of Engineers dams should be reviewed in light of new operation practices.

Model studies would be very costly but prototype studies in conjunction with existing guidelines would probably be adequate for development of spill schedules which are greatly needed at the public utility district dams.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the review development and adoption of powerhouse flow and spill criteria for the Columbia and Snake river dams.

Task 2.1.2: Establish flow requirements for optimum adult fish passage for each hydroelectric facility on the Columbia and Snake Rivers that have fish passage facilities

Needed research is currently underway to determine the effects of reduced and zero instantaneous flows during portions of the day on adult fish migrants. Minimum instantaneous flows in conjunction with minimum daily average flows ere used in flow recommendations prepared by the Columbia River Fisheries Council. This was done to address peaking operations which were demonstrated to have significant influences on adult fish passage (Junge, 1971). Available evidence indicates that the most severe effects of peaking on adult fish passage is not the low or zero flow but the increased flows through the powerhouse. Currently, radio-tracking studies are being conducted by National Marine Fisheries Service to determine behavior of adult salmon and steelhead passage under low and zero flow conditions. The results should be incorporated into dam projects operating standards.

Development of adult flow requirements must consider the needs of the juvenile migration to assure no conflict.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program flow criteria developed through ongoing research at Columbia and Snake River dams to assure efficient adult fish passage.

Task 2.1.3: Institute spill and flow guidelines (where applicable) and minimum flows for effective passage at hydroelectric projects on tributary streams.

The major emphasis and need for improved adult passage is on the Snake and Columbia rivers. However, significant anadromous fish runs are also impacted by passage at existing and new tributary hydroelectric projects and the Power Act does address the tributary hydroelectric projects. Tributary stream projects should be reviewed to determine the extent of any adult passage problems, data necessary to support improvements, and then recommend operating guidelines.

Task 2.1.3(a): Yakima River System

The Yakima system has three low-head hydroelectric dams that supply water to small hydroelectric projects. Low flows downstream of these projects do hinder or prevent adult passage. Recommendations (Washington Department of Fisheries) for instantaneous minimum flows below the three diversion dams are as follows:

1. Wapatox (Naches River) 250 cfs
2. Roza (Yakima River) 250 cfs
3. Prosser (Yakima River) 400 cfs

The above flows should be considered provisional as studies will be conducted in the future to confirm or refine these minimums. A detailed flow study is being conducted by the U.S. Fish and Wildlife Service under contract with the Bureau of Indian Affairs to obtain base flow requirements for adult fish passage in the Yakima Basin.

Discussions between fisheries agencies and the irrigation districts are in progress relative to establishing minimum flows at critical points in the Yakima River system including those downstream of the three hydroelectric diversion dams.

Recommendation: That the Power Planning Council provide programmatic support to minimum flows in the Yakima River and include in its Fish and Wildlife Program those flows required for adult fish passage as determined by current instream flow studies.

Task 2.1.3(b): Santiam Basin-Green Peter Dam

Introduction: The Green Peter-Foster Dam complex was completed on the South and Middle Santiam rivers in 1969. Green Peter Dam began impounding water in 1966 and is located on the Middle Santiam River 10 km above Foster Dam. Foster Dam is located on the South Santiam and impounds water from the upper South Santiam and Middle Santiam Rivers. The native winter steelhead run above Foster Dam has declined from an estimated 1,900 adults to less than 500 annually from 1973 to 1981. Prior to construction of the project, 60 to 70 percent of the wild steelhead production was estimated to have occurred in the Middle Fork. After construction of Green Peter Dam, less than 31 percent of the adults passing Foster Dam are returning to the Middle Fork. This lower percentage may be due to rejection by adult steelhead of either high or low flows due to power peaking discharges from Green Peter Dam. Green Peter will discharge approximately 4,000 cfs during peak power use and is required to provide a continuous discharge of 50 cfs. Rejection of the Green Power discharge may cause winter steelhead adults to spawn in less suitable areas, thus lowering the total production of the South Santiam run.

Current Status: Only 31 percent of the wild steelhead adults passed over Foster Dam in 1967 returned to the Green Peter adult trap. This percentage was further reduced to an average of 19 percent from 1967 to 1972 (Wagner and Ingram 1973). Continued monitoring has documented that no adults returned to Green Peter trap in 1979 and 1980 and only 13 adults in 1981.

A research study is necessary to determine possible solutions to the decreasing runs destined for the Middle Santiam River. This study needs to determine how maximum and minimum or various combinations of flows affect adult steelhead movement. Steelhead movement in Foster Reservoir and Green Peter Reservoir must also be monitored to determine possible delay in the reservoirs. Spawning and rearing areas above Green Peter need to be assessed to determine if drastic alterations have occurred. Steelhead smolt emigration through the Green Peter downstream migrant facility needs to be monitored.

The expected result would be to clearly identified that returning steelhead adults are being confused or delayed at the Green Peter-Foster Project. Other possible alterations to steelhead production in upper Middle Santiam would be monitored to verify this hypothesis. The study should further determine if delay or confusion is occurring in Foster Reservoir, in the middle Santiam between Foster Reservoir and Green Peter Dam, immediately below the Green Peter adult trap, or in Green Peter Reservoir. An expected result would be the determination of adult steelhead movement at minimum and maximum output from Green Peter Dam. Solution to this problem would allow additional production to occur above Green Peter Dam and help to restore the run of native winter steelhead to 1,900 adults passing Foster Dam annually.

Scope of Work

Objective 1: Determine any recent alterations to steelhead spawning or rearing habitat in the Middle Santiam above Green Peter Dam.

Objective 2: Determine success of steelhead smolt emigration through the Green Peter-Foster Project.

Objective 3: Determine the percent of recycling of wild adult steelhead at Foster Dam.

Objective 4: Determine movement and timing of hatchery adult steelhead returning from a release above Green Peter Dam. Movements will be monitored with the use of radio-tags.

Objective 5: Determine movement and timing of wild adult steelhead above Foster Dam. Movements through the Green Peter-Foster Project will be done using radio-tags.

Recommendations: That the Power Planning Council include in its Fish and Wildlife Program Corps of Engineers' funded research to determine the effect of fluctuating Green Peter flows on the maintenance of the steelhead run in the South and Middle Santiam rivers. Based on research results necessary

operating guidelines should be adopted and/or facilities constructed, and compensation for any unavoidable losses.

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Task 2.1.3(c): Clackamas River

Introduction: Three Portland General Electric Company dams on the Clackamas River have been historic barriers to anadromous fish migration. Adults moving up the river encounter River Mill Dam, where an antiquated fishway was modified in the mid-1970's to more effectively pass adult fish. Migrating fish enter River Mill forebay and pass upstream toward Faraday Dam, where a fishway bypasses adults around Faraday Reservoir into the forebay of North Fork Dam. However, little river flow exists in the main river channel between Faraday Dam and powerhouse discharge. Adult anadromous fish are delayed by the powerhouse discharge instead of moving upstream and passing above North Fork Dam. Little spawning area exists in the vicinity of the Faraday powerhouse. Fish passage through this critical stretch of approximately ½ mile of stream above the Faraday powerhouse must be evaluated to determine:

1. Acceptable minimum flows to effectively attract adults from Faraday powerhouse to the entrance to the North Fork fishway.

2. Operation schedules at the Faraday project that could be used to attract fish effectively via periodic spill.

Current Status: Chinook and summer steelhead passing River Mill Dam contributed to the urgency of solving this problem. In addition, the approximate two-mile length of the North Fork fishway has apparently contributed to a delay in adult passage through the facility. This delay should be quantified, with the prospect of requiring intensified trapping and hauling operation from the entrance of the North Fork ladder to areas above North Fork Dam to reduce migration delay.

A research project should be undertaken to better document suspected migration delays, causes of delay, and potential solutions. The study would include trapping of adults at River Mill fishway in conjunction with observations of adults in the river and spill regimes at Faraday Dam. Trapped adults would be tagged and released into the fishway. Tagged fish and time

of passage would be recovered at the North Fork trap to define passage delays.

Results: Since no emigrant passage facilities are provided at River Mill Dam, high mortality on juveniles which result from spawning in the Faraday discharge area are suspected. Based on differential chinook counts at River Mill and North Fork in 1973 and 1974, about 35 percent of the fish which ascend River Mill do not cross North Fork ladder. Recent counts of chinook at North Fork have exceeded 2,000 fish per year. In addition, substantial populations of summer and winter steelhead and coho salmon cross River Mill Dam. We estimate that more effective fish passage at North Fork would result in an increased upstream passage of at least 1,000 adult spring chinook per year. A catch-to-escapement ratio of 1.3 would result in partial net economic fishery benefits for chinook alone of approximately $466,000 per year. Additional benefits would accrue to summer steelhead.

Costs: A cost will be associated with power loss due to spill at Faraday Dam. However, this cost will vary depending on increased minimum flow requirements and frequency and duration of spill periods. These parameters will be determined by the study.

Operations: Should an intensified trapping and hauling operation be required at North Fork fishway, additional costs of up to $25,000 annually may result. No additional costs of manipulation of additional spills (exclusive of power loss costs) are anticipated with this option.

Scope:

1. Record fish passage efficiency between River Mill ladder and North Fork fishway under a variety of spill conditions from Faraday Dam. Install camera and counter at River Mill fishway.

2. Tag fish at River Mill trap and monitor timing of passage to North Fork ladder trap to define delays.

3. Recommend duration and volume of spill from Faraday that meets acceptable efficiencies for upstream passage.

3. Recommend duration and volume of spill from Faraday that meets acceptable efficiencies for upstream passage.

4. Recommend frequency and timing of fish hauling operations from North Fork fish trap to optimize passage above the North Fork-Faraday complex.

Recommendations: That the Power Planning Council include in its Fish and Wildlife Program research to document and resolve adult fish passage problems associated with the Portland General Electric Company's Clackamas River hydroelectric complex.

Task 2.1.3(d): Tumwater Dam

Introduction: Tumwater Dam is located on the Wenatchee River at R.M. 32.7. The project was constructed in 1909 and was operated until 1957 when the cost of essential repairs and improvements made the cost of power unreasonable with other available sources.

The problems associated with the project are similar to those discussed in Task 2.1.3(e). At Tumwater, diversion of river flows lowered the river level to the extent that adult fish were unable to pass upstream over the shallow riffles. A significant amount of anadromous fish production occurs above the project. Based on the importance and value of existing and potential runs, anadromous fish access to spawning and rearing habitat available in the uuper Wenatchee is essential.

Current Status: The existing fish ladders at both Tumwater and Dryden have been the subject of considerable controversy in recent years. Both facilities are considered obsolete and inadequate by current engineering criteria.

Chelan County PUD has title to the project and has water rights to divert up to 1,400 cfs for power generation. They have a preliminary permit from the FERC and are currently studying the feasibility of rehabilitating the project for power generation.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program efforts to document and resolve fish passage problems associated with Chelan County's Tumwater Hydropower Project.

Task 2.1.3(e): Dryden Dam

Introduction: The Wenatchee River contributes significant natural production of anadromous fish. In 1978, the Washington Department of Fisheries estimated that 6,000 spring chinook, 8,000 summer chinook, 1,000 coho, and 20,000 sockeye salmon spawn in the Wenatchee River system. There is also an unquantified amount of steelhead trout natural production. Most natural production occurs above Dryden Dam located at R.M. 17.5. The Fish and Wildlife Service also operates Leavenworth National Fish Hatchery which is located on Icicle Creek, 8 miles above Dryden Dam. Therefore, efficient and timely upriver access is very important to the continuance of these stocks.

The Dryden Hydroelectric Project was built in 1907 and operated until 1957 when power production was abandoned because of high annual costs. The dam originally had two fish ladders but the lowermost facility washed out in 1948 and was not replaced. The remaining facility still operates but is inadequate by current standards.

When the project was operated there were problems with both up and downstream migration. Largely due to project operation for 50 years, the eight-foot dam diverted virtually the entire low flow in late July through early October from the 1.3 mile section of the river between the diversion and the powerhouse. Typically power dams are located in the steepest reaches at hydrologic control points so as to maximize generating capacity. Such siting may amplify passage problems as the river section may be naturally difficult to traverse. A 1948 Fish and Wildlife Service study reported some of the undesirable effects of project operation. During low-flow periods fish were attracted to the proportionally higher powerhouse tailrace flow and shunned the much lower flow in the river channel. This delayed, if not altogether stopped, their upstream migration. As a result, extensive chinook and sockeye salmon losses occurred due to stranding, disruption of normal run-timing, forced massed spawning where previously deposited eggs were disturbed by subsequent spawning and exposure to prolonged higher water temperatures typical of the lower river.

Current Status: Chelan County PUD owns title to the project including rights to divert a total of 1,300 cfs for the purpose of power production and irrigation. The PUD has an obligation to deliver up to 2,000 cfs of the total to the Wenatchee Reclamation District between mid-April and mid-October. The PUD is presently investigating the rehabilitation of the project under a FERC preliminary permit. Although, fish passage recommendations have been made by applicable fishery agencies and improved passage may be required by FERC license, there is no assurance for its implementation.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program efforts to document and resolve adult fish passage problems associated with Chelan County's Dryden hydroelectric complex.

LITERATURE CITED

FISH, F.F. and M.G. HANAVAN
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1980. Dryden hydroelectric project draft environmental impact statement. Chelan County PUD, Wenatchee, WA, 174p., plus appendices.

Subobjective 2.2: Provide for the operation, maintenance, and necessary modification of adult fish passage facilities at mainstem and tributary dams to achieve optimal attraction and unimpeded passage upstream during the entire adult migration period.

General Description of Adult Passage Facilities: Hydropower dams almost without exception block adult passage by creating a physical barrier across a stream and a water surface differential from upstream to downstream of the structure which prevents fish passage upstream unless special facilities are provided. Passage facilities must present hydraulic conditions corresponding with the swimming ability and migrational behavior of the particular species concerned to function effectively. Primary criteria for passage is the avoidance of delay, stress, and injury, any one or combination of which adversely affects survival, catch, and reproduction.

An adult passage facility includes several components, every one of which must be designed and operated to assure successful passage. These are (1) the collection facility located at or near the downstream face of the dam. Fish entrances must be provided at the most appropriate locations, that is where fish naturally congregate at the base of the dam in their upstream migration. Entrances discharging adequate quantities of water at appropriate velocities are eeded to attract fish searching for a strong well-defined flow. Fish pass through the entrance openings into a collection area. (2) An auxiliary attraction water supply. Water in addition to that flowing down the fish ladder is needed to provide adequate quantities of flow out the fish entrances to attract adults to enter the collection system from the river. The quantities of flow may range from 100 cfs or less at smaller tributary dams to several thousand cfs at larger dams. At mainstem Columbia dams adult attraction flows vary from approximately 2,500 cfs at Rock Island Dam to more than 6,000 cfs at Bonneville and The Dalles dams, and equal 1 to 2 percent of the powerhouse hydraulic capacity. At most projects the auxiliary attraction flow passes through turbines generating power prior to fishway use. (3) A fish ladder to allow the fish to gain the elevation necessary to bring them to the level of the

forebay upstream of the dam. Design of the ladder proper is rather standardized in that it consists of a channel with weirs which form a series of pools at successively higher elevations progressing up the ladder. Dimensions and quantity of flow for ladders have been established through past research and they are relatively trouble-free. (4) An exit control section located at the upper end of the ladder. The purpose of this part of the facility is to provide the fish an exit from the ladder returning them to the river upstream of the dam at a location favorable to their continued upstream migration. It also operates to provide the correct quantity of flow down the ladder. (5) A fish counting station. This facility is usually provided at some location along the fishway to provide access for viewing the fish for the purpose of numbers of each species passing the dam. Fish counts are required to quantify runs for fisheries management purposes and determine effectiveness of passage conditions.

The above passage facility components must be constructed and operated to provide quantities of flow, velocities and water surface elevations conducive to fish migration at all times fish are present or potentially.

To determine the effectiveness of adult passage facilities requires evaluation studies be conducted at each facility upon completion of construction. These studies are aimed at defining particular structural and flow conditions associated with the facilities which cause delay or injury. They also provide a method for verifying or refining operation guidelines for the facility. Tracking the movement of test fish through the facility during various modes of powerhouse and spillway operation is a primary method of evaluation.

Analysis of counting station fish counts at the project under study and at successive projects also points out problem areas. A primary example of this type of problem is the greatly increased loss of bright fall chinook between Bonneville and McNary dams since 1979. Whereas prior to 1980 the unaccounted for loss of adult migrants averaged 34 percent of the run; the 1980 loss rate was 51 percent; and the 1981 loss rate may be even higher. There are several possible explanations for the increased losses, including higher mortalities during passage around dams in the lower Columbia River.

A major problem at many hydro projects continues to be providing effective fish entrance conditions at the base of the dam. Construction of the new Bonneville Second Powerhouse and modification of the Bonneville Old Powerhouse fish collection system currently under will require post-construction evaluation as to effectiveness. With the second powerhouse in operation, spillway discharge will be greatly reduced and operation of the first powerhouse will be significantly changed. Effects of these changes on migration paths in the area of the project must be evaluated to assist in establishing spillway and powerhouse operational criteria favorable to passage. Impacts of powerhouse and spillway operations on adult passage at Columbia River dams are documented in numerous reports some of which are noted below. Several of these studies are carried out at the Bonneville project.

Modification of the John Day collection facility is needed as documented in the Corps of Engineers May 1974 report on John Day Lock and Dam Powerhouse Fish Collection Studies (USCE, 1974), and additional 1979 and 1980 Corps of Engineers studies (USCE, 1980).

Construction of new vertical board adult fish counting stations at The Dalles Dam fishways similar to other Lower Columbia dams is needed to provide accurate counts and minimize passage delay (USCE, 1978).

Fishway operating standards have been developed and implemented for Corps of Engineers on the Columbia and Lower Snake Rivers (Columbia River Fisheries Council letter to Corps of Engineers, North Pacific Division, June 4, 1981). Similar guidelines remain to be finalized for the five public utility district dams on the mid-Columbia. Numerous tributary dams also lack established operating guidelines, including those on the Willamette Rivers and other streams. The regional demand for hydropower generation continually places the use of water for adult fish passage in question by power interests since ladder flows cannot be used for power generation, and auxiliary attraction flows result in reduced power production. Established operating criteria for each project are necessary to provide both fisheries personnel and project operators a common basis by which satisfactory passage is provided with a minimum use of water and misunderstanding. In recent years fisheries agencies have received several proposals from the Corps of Engineers and

Grant County Public Utility District No. 1 to reduce or shut off entirely flows in certain ladders at mid-Columbia and Lower Snake River projects. Fishway operations including fish ladder and entrance flows, must be in accordance with criteria which support requirements of project licenses and authorizations.

As stated above, provision of adequate auxiliary attraction water at the fishway entrances is critical to effective passage. At several projects auxiliary water is supplied by pumps. The pumps at Lower Granite, Little Goose, and John Day dams have experienced operational problems on numerous occasions. The need exists to provide a more reliable auxiliary water supply at these projects. This need has been documented in correspondence between the Corps of Engineers and the fishery agencies, the latest of which is the Columbia River Fisheries Council letter of August 25, 1981, to the Walla Walla District Engineer.

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1980. Fisheries research and protection program annual progress report.

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1974. John Day Lock and Dam Powerhouse fish collection studies.

U.S. ARMY CORPS OF ENGINEERS, PORTLAND DISTRICT
1978. The Dalles Dam Powerhouse fish collection system studies.

Task 2.2.1: Institute fishway operating guidelines for optimal fish passage

The guidelines have already been substantially completed for Corps of Engineers dams on Columbia and Snake rivers with fish facilities. Around 1966 Oregon Department of Fish and Wildlife initiated development of adult fish passage criteria for Corps of Engineers dams on the Columbia and Snake rivers. The criteria was developed by adjusting flow conditions in the fish facilities from the original design to maximize fish counts through fish counting stations selected for the studies (unpublished). It was found for instance that wider (12 - 15 feet) and shallower (8 - 10 feet) fishway entrances pulled in fish much better than narrow (3 - 6 feet) and deeper (15 - 30 feet) entrances. At the same time it was discovered that horizontal streaming flows out the entrances was much more effective than plunging flows that dissipated most of the energy at the gate rather than downstream in the tailrace as required to pull in fish. Along with the streaming flow condition it was determined that better attraction conditions also existed if the fish attraction pumps or fish turbine units were run at a fixed capacity (at or near maximum) all the time rather than fluctuated as designed to maintain certain head on the entrances. The latest Corps of Engineers dams that are still operating on "as design" standards need to be updated to the newer criteria. A similar process needs to be established for the mid-Columbia and tributary dams.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the fishway operating criteria developed for the Corps of Engineers projects and the need to develop and implement passage criteria at the five mid-Columbia and necessary tributary projects.

LITERATURE CITED

JUNGE, CO.
1971. Effects of peaking operations on passage of adult salmonid over Columbia River dams. Final Report to U.S. Army Corps of Engineers. Contract DACW 68-71-C-0020. 12pp.

Task 2.2.2: Conduct post construction evaluation studies of new adult fish facilities at all projects with expanded powerhouse facilities to determine their effectiveness

As mentioned in Task 2.2.1, flows at fishway entrances need to be studied to determine if the designed operations are most effective under actual operating conditions. Past studies at other dams on the Columbia and Snake rivers such as The Dalles and Ice Harbor indicated that other criteria than the original design was more effective in leading fish into fish entrances. Other areas of concern in the past in fish facilities at new dams have been tunnels, trifurcation pools, float orifices, and lighting. In addition, second powerhouse studies should be made to determine use of upstream and downstream entrances and why some species are passing at night, up to 25 percent. A night factor may be required. Studies should also be required to determine what mode of operation between the old and new powerhouse will create the least passage delay.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program operation criteria for adult fish passage at each project for which electrical generation capacity is expanded.

Task 2.2.3: Construct new counting stations at the existing fishways at The Dalles Dam to provide accurate quantification of runs

The Dalles Dam is the only Corps of Engineers dam on the Columbia and Snake rivers with anticipated horizontal rather than vertical counting boards in the counting stations. Accurate fish counts are necessary for management purposes and to determine the effectiveness of fish passage facilities. During the spring period when the river is most turbid and the largest run of fish are passing the dam, the horizontal counting boards are raised to a shallow level so the fish can be identified. Based on Corps of Engineers (USCE, 1978) investigations, these conditions create delays and mortalities. Ripples on the water surface and glare on the water cause poor counting conditions and may be one reason for count differences between adjoining dams. Preliminary design of new stations by the Corps of Engineers have been tentatively approved by the fishery agencies. The plans and specifications should be finalized and the stations built as soon as possible.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the construction of a new fish counting facility at The Dalles Dam by the Corps of Engineers.

Task 2.2.4: Improve the adult attraction system at John Day Dam. Evaluate research and develop and implement modifications to the facility needed to reduce passage delay and mortality previously documented.

Powerhouse attraction studies researched in 1972-73 (Duncan, et al., 1974) showed that unit No. 1 turbine discharge influenced fish entry rate into the south shore entrance (SE1). The study concluded that reduced flows through turbine No. 1 increased fish passage into SE1. Now with the ever increasing demand for power it is highly probable that unit No. 1 will be operated at peak levels much of the time. It is therefore essential that SE1 be modified to discharge at a more effective location relative to unit No. 1.

Presently, very significant numbers of adult fall chinook destined for the upper basin are being lost between The Dalles and John Day Dam counting stations. The unaccounted losses may be due to passage conditions at John Day Dam. Resolution of this problem should be included in the studies.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the immediate modification of adult fish passage facilities at John Day to improve fish survival.

LITERATURE CITED

U.S. ARMY CORPS OF ENGINEERS, PORTLAND DISTRICT, Duncan et al. John Day Dam Powerhouse Fish Collection Studies 1972-1973. John Day Lock and Dam Powerhouse Fish Collection Studies 1974.

Task 2.2.5: Provide permanent solution to the problem of unreliable pumps which supply fishway auxiliary water

Operation of pumps to provide auxiliary attraction flows are critical to achieving proper fishway attraction and entrance conditions and therefore reducing fish delay and mortality. The pumps at Lower Granite Dam have had reoccurring breakdowns during critical passage periods due to gearbox failures. Problems have also been experienced with the pumps at John Day and Little Goose dams. Lower Monumental Dam has pumps of similar design and problem potential.

Since the completion of Lower Granite Dam in 1975 the fish attraction pumps have created problems by breaking down and being unreliable, sometimes during the peak of fish runs. The fishery agencies have requested the Corps of Engineers since 1976 to install better designed, more reliable fish pumps. In 1977 fishery agencies met with Corps of Engineers officials in an attempt to resolve the problem, so far the piecemeal solution of obtaining standby gear boxes has not proven satisfactory. This year, at the start of the fish run, only one pump was available for operation at Lower Granite. This reduced total fish attraction from about 2,400cfs to 1,050 cfs thereby reducing efficient adult passage. Because of the tremendously noisy level of the pumps, any work required in the pump room is slowed down to a snail-pace by communication problems.

John Day pumps are of the same design only larger capacity. They also have broken down frequently during fish passage seasons and are considered unreliable. The standby gearbox requires several days to install and at least once the whole pump room was shut down while the work was performed because of the high noise level to the workers. Lower Monumental and Little Goose dams pumps are of a similar design and have caused problems in the past, although Lower Monumental has not had a pump outage lately. The pump problems need to be resolved to help reduce fish losses at the dams and provide a more satisfactory operating condition.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the immediate replacement by the Corps of Engineers of unsatisfactory auxiliary water supply pumps at its Columbia and Snake River projects.

Task 2.2.6: Willamette Falls adult trapping facilities

Introduction: The fishway at Willamette Falls provides entrance to the upper Willamette Basin for virtually all anadromous fish destined for upriver areas. Currently 30 to 50 percent of the annual spring chinook run counted past Willamette Falls cannot be accounted for at upstream locations. The capability of efficiently catching adult fish as they ascend the fishway will permit the collection of a variety of biological data to further management of the anadromous fish runs.

Current Status: A fish trap capable of selectively trapping adults which enter one leg of the fishway has been installed on a prototype level. Once improved and made effective, this trap will provide the capability of either removing previously-tagged fish or collecting random samples of live adults for tagging or biological sampling.

Needed Research:

1. Complete and perfect the existing fish trap in leg A of the Willamette Falls fishway.

2. Collect random samples of adults crossing Willamette Falls to provide data on run status (size, age, scales, marks, etc.).

3. Conduct adult tagging operation to provide data related to timing of passage vs. return location, upstream return timing, delay, fallback, wild fish component and pre-spawning mortality. A total of four years would be needed to complete the study. The estimated study cost for FY 83 would be $10,000 for completion of the trap, plus $80,000 with a total funding requirement for four years.

Results: Development of full potential for wild and hatchery-reared salmonids in the Willamette Basin depends largely on availability of good biological data upon which to base management decisions. We estimate that data derived in

an effective adult trap at Willamette Falls will provide increases of up to 10 percent in adult returns to the upper Willamette River.

Scope: A fish trap in this lower river lcoation will provide data related to:

1. Random sampling of the adult population for biological parameters (size, age, scale analyses).

2. Efficient recapture of random samples of coded-wire tagged fish throughout the duration of the run.

3. Efficient tagging capability of random samples of adults throughout the duration of the run, to determine:

   A. Relationship between falls passage timing vs. location of return upstream.

   B. Relationship between falls passage tıming and timing of return to upstream facilities.

   C. Relationship between falls passage timing and degree to pre-spawning mortality sustained.

   D. Relationship between falls passage tıming and potential fallback.

4. Potential brood stock selection from a lower river area before the potential spawners pass through intensive fisheries.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program the installation and operation of an adult trapping facility at Willamette Falls.

Task 2.2.7: Analyze adult fish counts at mid-Columbia public utility district dams to determine if losses between dams is occurring.

Unaccounted losses of adult migrants have been assessed at certain Corps of Engineers dams based on analysis of counts and use of tags (Gibson, et al., 1979). Similar analyses are needed for mid-Columbia dams to provide critical base information on the effectiveness of existing fishways and their operations.

Recommendation: That the Power Planning Council include in its Fish and Wildlife Program a study of adult fish counts at mid-Columbia dams to determine potential problems in effectiveness of existing fishway operations.